St. Petersburg State University

Graduate School of Management

Master in Corporate Finance

ANALYSIS OF THE RELATION BETWEEN INNOVATION ACTIVITY AND FINANCIAL PERFORMANCE OF RUSSIAN COMPANIES

Master's Thesis by the 2nd year student

Concentration – Master in Corporate Finance

Ekaterina Shumilova

Research advisor:

Egor D. Nikulin, Senior Lecturer

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ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

Я, Шумилова Екатерина, студентка второго курса магистратуры направления «Менеджмент», заявляю, что в моей магистерской диссертации на тему «Взаимосвязь между инновационной активностью и финансовой результативностью российских компаний», представленной в службу обеспечения программ магистратуры для последующей передачи в государственную аттестационную комиссию для публичной защиты, не содержится элементов плагиата.

Все прямые заимствования из печатных и электронных источников, а также из защищенных ранее выпускных квалификационных работ, кандидатских и докторских диссертаций имеют соответствующие ссылки.

Мне известно содержание п. 9.7.1 Правил обучения по основным образовательным программам высшего и среднего профессионального образования в СПбГУ о том, что «ВКР выполняется индивидуально каждым студентом под руководством назначенного ему научного руководителя», и п. 51 Устава федерального государственного бюджетного образовательного учреждения высшего образования «Санкт-Петербургский государственный университет» о том, что «студент подлежит отчислению из Санкт-Петербургского университета за представление курсовой или выпускной квалификационной работы, выполненной другим лицом (лицами)».

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I, Shumilova Ekaterina, second year master student, program «Management», state that my master thesis on the topic «Analysis of the relation between innovation activity and financial performance of Russian companies», which is presented to the Master Office to be submitted to the Official Defense Committee for the public defense, does not contain any elements of plagiarism.

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Аннотация

Автор	Шумилова Екатерина Константиновна
Название магистерской диссертации	Взаимосвязь между инновационной активностью и финансовой результативностью российских компаний
Факультет	Высшая Школа Менеджмента
Направление подготовки	Корпоративные финансы
Год	2018
Научный Руководитель	Никулин Егор Дмитриевич, Доцент
Описание целей, задач и основных результатов	Цель данного исследования – выявление взаимосвязи между инновационной активностью и финансовой результативностью российских компаний. Для достижения поставленных целей был проведен обзор литературы по показателям финансовой результативности и инновационной деятельности и исследованию их взаимосвязи. Кроме того, были исследованы внутренние факторы, которые являются детерминантами инвестиций в НИОКР. На основе теоретического обзора было проведено эмпирическое исследование данной взаимосвязи на примере российских публичных компаний с помощью регрессионного анализа. Анализ регрессии показал, что имеет место нелинейная взаимозависимость между результатами НИОКР и финансовой результативностью российских компаний, как для бухгалтерской, так и для рыночной результативности. Более того, существует положительная взаимосвязь внутренних ресурсов компании, таких как размер фирмы, качество персонала и капиталоемкость, с результатами НИОКР. Также была найдена отрицательная взаимозависимость между финансовым рычагом и результатами НИОКР.
Ключевые слова	Инновационная активность, НИОКР, патенты, стоимость фирмы, финансовая результативность

Abstract

Master Student's Name	Ekaterina Shumilova
Master Thesis Title	Analysis of the Relation Between Innovation Activity and Financial Performance of Russian companies
Faculty	Graduate School of Management
Main field of study	Corporate Finance
Year	2018
Academic Advisor's Name	Egor D. Nikulin, Senior Lecturer
Description of the goal, task and main results	The goal of the research is to identify the relationship between innovation activity and financial performance of Russian companies. To achieve this goal the literature review on financial performance, innovation activity and justification of their relationship was provided. Moreover, there was investigated internal factors that may have interrelation with R&D investment. On the base of theoretical review the empirical investigating this relationship was performed on the sample of Russian public companies using regression analysis. The regression analysis identified a non-linear correlation between results of R&D and financial performance in Russian public companies for both accounting-based and market-based performance. Furthermore, there is a positive correlation between firm's internal resources such as company's size, quality of human resources, capital intensity and R&D results. Likewise, there was found a negative correlation between company's leverage and its R&D intensity.
Keywords	Innovation activity, R&D investment, patents, firm value, financial performance

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Introduction

Making essential decisions it is necessary to have a deep understanding, whether this decision improve the firm's performance, and hence, increase the company value and performance. Currently, innovation activity is increasingly understood as essential for the long-term sustainability and performance of any enterprise. This is due to the fact that firm's performance is highly dependent on its ability to quickly adapt to rapidly changing external environment, and thus the ability to innovate.

Nowadays, following the trend of the world economy along the path of innovative development, the Russian economy faces the task of moving from an export-oriented to an innovative socially-oriented type of development that becomes the main strategic objective stated by the Strategy of Innovation Development 2020 (Analytical Center under the Government of the Russian Federation, 2014). In this regard, an enhancement of innovative activity of Russian companies is of substantial importance. Furthermore, the leading role in the global innovation process belongs to the large companies since they possess all the necessary intellectual and financial resources. The importance of innovation activity is verified by the executives of Russian companies. They confirm that the long-term growth of their business would be impossible without implementing of innovation. According to 43% of interviewed senior executives, innovations are becoming an increasingly important condition for maintaining the competitiveness of the organization (PWC, 2013).

Over the last decade, the academic literature provided evidences of the important role played by innovation activities in economic growth. Scholars have paid increasing attention to the R&D expenditures, which is no longer considered a cost but rather a value-increasing investment. However, this question is raised in many modern European and American studies, but in Russia this aspect remains unexplored. Therefore, it is crucial to determine whether the innovation activities are also effective in Russia and lead to the increase of company's performance.

Research goal:

To identify the relationship between innovation activity and financial performance of Russian companies.

Research questions:

Consequently, the key question of this paper is whether the innovation activity is related to the market-based and accounting-based financial performance and what are the features of this relationship?

Research objectives:

1) To provide an analysis of firm's financial performance and choose the most appropriate indicators for the purpose of the current research;
2) To analyze approaches to defining the "innovation" and "innovation activity";
3) To present the theoretical justification of the model investigating the relationship between the innovation activity and financial performance;
4) To provide a theoretical analysis of the factors that may affect the innovation activity of the company
5) To conduct an empirical research revealing the relationship between innovation activity and financial performance of Russian companies
6) To conduct an empirical study on factors that may affect the firm's R&D investment decisions

The paper is structured according to the set objectives and includes an introduction, three main chapters, a conclusion, a list of references and applications.

The first part is dedicated to the literature review on innovation activities and firm's financial performance. First, we consider the most common indicators of financial performance both accounting-based and market-based. Then, we specify what do we mean by innovation, examine the innovation and innovation activities definitions and consider its main characteristics. Moreover, we investigate how innovation activities can be measured based on the previous researches and what factors affect R&D investment as the most commonly applied indicator of firm's innovation activity.

The second chapter is dedicated to the empirical study of relationship between innovation activity and financial performance. Here we state the hypotheses, define the methodology of the empirical research, justify the data selection process and provide the data description analysis.

In the third chapter we provide the results of econometric analysis, confirm or reject hypotheses on the relationship between innovation activity and company's performance, make conclusions and provide the recommendation based on the regression analysis. As a final point we provide the managerial implications of the conducted research.

The study on the relationship between innovation activity and firm's financial performance was performed using econometric analysis on the base of the econometric tool "Stata". The study was conducted on a sample of Russian public companies, which in the period from 2012 to 2016 carried the of research and development expenditures and patents' registration, which could be used in their core business.

Chapter 1. Theoretical research on innovation activity and company's financial performance

1.1. Financial performance indicators

Generally, financial performance metrics are aimed to reflect how well the business has done. In management theory and practice there is a large number of financial performance indicators associated with various items of the balance sheet or types of firm's activity. Since this research is dedicated to the analysis of relationship between innovation activity and company's financial performance, it is necessary to consider main evaluation metrics of companies' performance taking into account the purpose, benefits and drawbacks of each indicator. Usually a certain indicator characterize the company from a separate point of view and focuses on particular characteristics of business, therefore in most cases it is impossible to choose one universal indicator that would give a complete picture of the company position.

According to D. Parmenter, there are three levels of performance measurement, which he associates with onion parts (see Figure 1). The skin part reflect the overall condition of the company; if we peel the skin, we will find more information that, in its turn, leads us to the central part with key performance indicators that is the core of company performance. In management terms, these are the following levels (Parmenter, 2015):

1) Key results indicators (KRI's) are performance measures that determine how you perform in a perspective and whether the set objectives were achieved. The KRI's give the overall picture about the company position and assess whether it move in the right direction. However, it does not tell how to improve the results if they are far from the ideal picture. The example of KRI's can be net income, customer and employee satisfaction, return on capital employed, etc. There should be no more than 10 of such indicators.
2) Performance indicators (PI's) are the indicators that give more detailed picture of company's internal activities and become a base for the further choice of key performance indicators. They tell you what is needed to be done and can include the net income of a particular production line, sales increase of the top 10% of customers and so on. The number of such indicators tend to be larger than for KRI's and may achieve 80 for the company.
3) Key performance indicators (KPI's) are the "true" performance measures that are vital for the current and further company development. These indicators have to meet certain characteristics: to be non-financial, frequently measured and under constant control of

top management. Moreover, they have to bring a significant and positive impact (positively affect the main critical success factors) and be obvious to each employee as they are aimed to motivate staff work better. In general, KPI's should answer the following question: how to significantly increase the performance of the company.

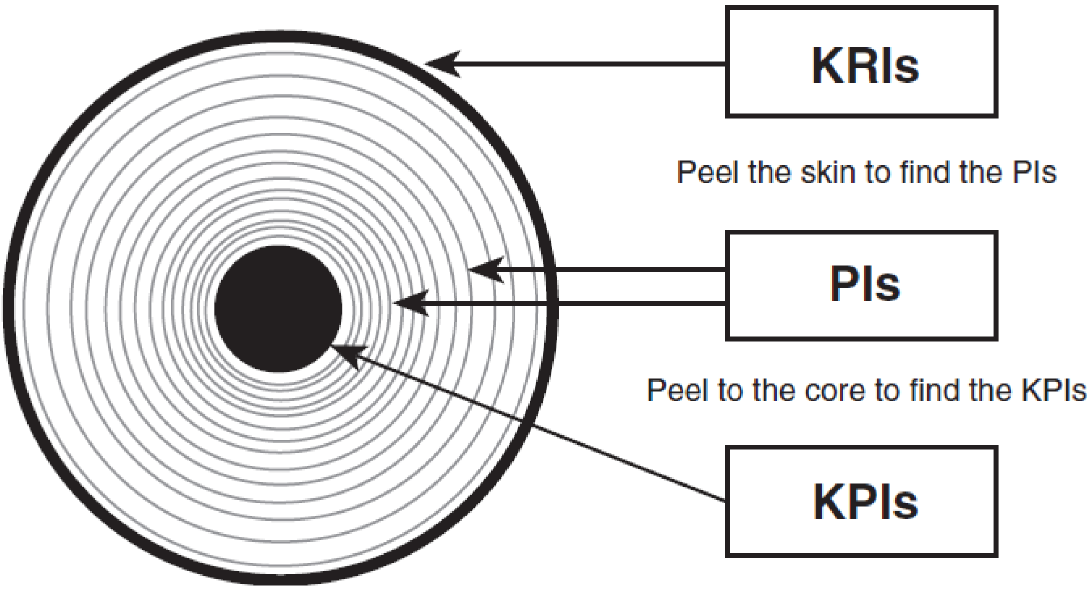

Figure 1. Three types of performance measures. (Parmenter, 2015).

There are different approaches to assess the company's financial performance. Basically, these indicators can be divided into two major groups: accounting-based and market-based performance. Further, we are going to focus on the most commonly used in previous researches metrics of both groups.

1.1.1. Accounting-based performance

Accounting-based performance is measured by the financial ratios of the company and represent its efficiency in terms of ability to generate profit, liquidity, financial structure and use of resource. Accounting statements published by companies are the main source for such indicators (for the public companies the publication of interim and annual financial statements is mandatory).

The majority of researchers use return on assets (ROA) as an indicator of accounting-based financial performance (Shin, Kraemer, Dedrick, 2017). Return on assets measures operating effectiveness of a company. It represents the profit available to debt and equity investors per dollar of the firm's total assets and is computed as following (Brealey, Myers and Allen, 2008):

$$ROA = \frac{Net\ Income + after - tax\ interest}{Total\ assets} * 100\%\ (1)$$

D. Volkov notes that this indicator is a better measure of performance in comparison with measuring instruments based on the indicators of income statement such as return on sales (ROS) (Volkov, 2008). This measure takes into account assets that were used for the business project implementation within the company and demonstrate the firm's ability to generate profit irrespective of its capital structure.

However, many researches that are devoted to firm's innovation activity often use return on sales (ROS) as an indicator of financial performance. The return on sales reflect the company's profit for each earned currency unit and can be useful both for the correct interpretation of company's turnover and further forecast of in terms of limited market volume constraining sales growth. In addition, this indicator is crucial for comparison of the effectiveness among business organization operating in the same industry (Brealey, Myers and Allen, 2008). This indicator is computed as following:

$$ROS = \frac{Net\ Income\ before\ interst\ and\ tax}{Sales} * 100\%\ (2)$$

C. Vithessonthi and O. Racela tested the relation between R&D and company's performance using both indicators – return on assets (ROA) and return on sales (ROS) and found negative relationship between them. Their finding prove their hypothesis that R&D investment can damage the financial performance of the company in the short-run prospective, but then lead to significant improvement of performance and competitive advantage in the long-run prospective (Vithessonthi and Racela, 2016).

Some other researches access the absolute estimate of net sales while examine the relation between innovations and firm's performance (Sismanoglu, Akcali, 2016). J. García-Manjóna and M. Romero-Merino investigate relationship between innovation activity and company's growth as its performance. For dependent variable they estimate growth as a difference of net sales logarithm for the current and previous year. As a result, they found that the correlation is more intense in fast-growing firms of high-technology industries (García-Manjón and Romero-Merino, 2012).

Another important performance indicator is a return on equity (ROE) that is focused on all aspects of the company's activity.

$$ROE = \frac{Net\ Income}{Shareholder's\ Equity} * 100\%\ (3)$$

In addition, the fact that ROE is a core factor for DuPont analysis, the use of this indicator became very popular among analysts, financial managers and shareholders (Firer et al., 2012). ROE can be represented as the product of three other indicators: profit margin (net profit to revenue ratio), asset turnover (revenue to assets ratio) and financial leverage (assets to equity ratio). Therefore, the DuPont analysis links the change of ROE to the change of three other factors and the possibility of such a representation is one of the main reasons for such a wide application of this indicator (Wet, Toit, 2007). Thus, ROE can be effectively improved by the more efficient use of assets or by increase if financial leverage. ROE appears in the study of P. Teirlinck where author confirms the significant correlation between R&D investments and firm's performance expressed as a return on equity (Teirlinck, 2017).

J. Hagel, J. Brown and L. Davison say that most analysts and investor perceive this this indicator as the best measure of the company's activity precisely from the investors' point of view, since this indicator shows how much profit is generated for the currency unit of shareholder's capital. Moreover, ROE is a good measure to define whether there was the shareholders' value creation (Hagel, Brown, Davison, 2010).

Return on Investment (ROI) is also one of the most frequently used accounting-based performance indicators of companies and computed as following:

$$ROI = \frac{Net\ Income}{Investment} * 100\%\ (4)$$

This indicator may be used to evaluate the company's ability to achieve the required profitability, assess the management performance and for future earnings forecast. Carrying out a comparative analysis of the investments effectiveness, managers can reasonably change the policy of development of the considered activity or product. It leads to the more optimal use of financial resources. Moreover, the relative value of this indicator allow to assess the effectiveness of products more efficiently, as the leaders in the absolute value profit list do not always give a high return on the invested funds (Dobb, Koller, 2005).

The accounting-based performance metrics sometimes can mislead the stakeholders. For instance, there may appear some errors related to the correspondence of the old and new projects. Another issue of accounting-based measures is biases of the accounting system and so-called "creative accounting" that is a set of legal methods by which an accountant, using his professional knowledge, increases the attractiveness of financial statements for stakeholders (Brealey, Myers and Allen, 2008). Therefore, due to some limitations of accounting-based metrics we are going to consider common market-based performance measures as well.

1.1.2. Market-based performance

Market-based performance is represented by the market value of the company and expresses the firm’s attractiveness to investors. There exist several studies that estimated the interrelation between the company’s innovation activity and its market valuation.

Most of researches rely on Tobin’s Q ratio. The research of M. Hirschey and R. Connolly analyze the relationship between R&D investment Tobin’s Q ratio and find state that the effect of R&D is greater for larger than for smaller firms (Hirschey and Conolly, 2005). J. Pindado, V. Querioz and C. Torre investigate not only the correlation of R&D with Tobin’s Q ration, but also the firms’ characteristics what can affect this indicator (Pindado, De Queiroz and De La Torre, 2010).

Tobin’s Q ratio was developed in 1968 by J. Tobin and W. Brainard. They define it as the ratio of assets market value to the replacement cost of these assets (Tobin and Brainard, 1977). However, approaches to calculation of Tobin’s Q may be different: it may be represented as the comparison of the company's market capitalization with the value of its net assets or comparison of the aggregated market price of company’s shares and bonds with the replacement value of its assets (Kovalev, 2004). One method for calculation is following (Wolfe, 2003):

$$Tobin's\ Q = \frac{Market\ Value + Debt}{Total\ Assets} \quad (5)$$

Nowadays, this indicator demonstrates how effectively companies manage their assets and derive value from them. It is focused on assessing the quality of the company's management. For instance, in case of ineffective management he firm’s market value will drop and become lower than its assets value; then, the Tobin’s Q ratio will take a low value (less than 1), demonstrating management issues (Damodaran, 2002). In the analysis of interrelation between R&D and company value this is the most frequently applied ratio reflecting the market attractiveness of investigated companies.

Another indicator based on market value and can be calculated only for public companies is total shareholders return (TSR):

$$TSR = \frac{Share\ Price_t - Share\ Price_{t-1} + Dividends}{Share\ Price_{t-1}} * 100\% \quad (6)$$

This indicator depends more on the changes on stock market than on specific managerial decisions, for this reason TSR is used mostly for the relative analysis within the examined industry. Nevertheless, the positive value of this indicator indicates that the market response to the top management decisions during this period was favorable. T. Koller, M. Goedhart and D. Wessels investigate the correlation between R&D and TSR, explaining the choice of this indicator by the fact that it represents the long-term shareholders value that is of great importance to the company performance (Koller, Goedhart and Wessels, 2015).

The market-based performance indicators have some limitations mostly because it rather takes into account expectations about the future of the company than the level of performance that it achieved during this period (Dobbs and Koller, 2005). In addition, it does not take into account the risks incurred by the company. At the same time obtaining higher profits may be associated with much higher level of risk that does not allow making accurate conclusion about financial results of this decision. Another issue can be the fact that even good work of top management may be underestimated due to the unfavorable market conditions.

To sum up, each indicator has a number of advantages and disadvantages and the choice of the right indicator should depend on the purpose of its usage. It should be noted that it is more appropriate to use several indicators for performance evaluation in order to assess results from different perspectives (Chen and Dodd, 1997). Therefore, in this paper we are going to evaluate both the accounting-based and market-based performance of the firms and its interdependence with companies' innovation activity.

1.2. Definition of innovation and innovation activity and its characteristics

Nowadays it becomes obvious that for effective performing on the market companies have to be able to reach certain results and keep pace with competitors. In this period of the intense competition in many industries and, therefore, continuous search of the new competitive advantage the innovation activity becomes a crucial part of the company's sustainable growth. Moreover, to achieve this sustainability it is necessary to develop innovation activity of the company on a long-term basis, but not as a one-time event. Furthermore, the innovation focus not only drives the company to the renovation processes and higher level of development, but also leads to the transformation of the whole industries.

However, it is necessary to determine what we are going to mean by the terms "innovation" and "innovation activity". It is crucial because the way the innovation for the particular organization has been defined directly influence the activities that will take place within the company. Academics and experts look at the definition from many perspectives, including both radical and incremental changes in products, markets and processes.

Initially, the innovation theory has been developed by Joseph Schumpeter. He interprets innovation as a process of development in five possible ways: new product or its quality; new method of production; new market; new supply sources; new organizational structure (Schumpeter, 1934). Peter Drucker defines innovation as a specific function of entrepreneurship

(Drucker, 2002). According to the Oslo Manual Guide innovation is “an implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations” (OECD/Eurostat, 2005). Hence, all these definitions rely on the process nature and suggests four possible forms of innovative outcomes: product, process, marketing and organizational methods. N. N. Molchanov approach it differently and directly focus on the end product: “Innovation is a result of intellectual or scientific and technical activity aimed at the improvement of social practice by satisfying customers that are not ensured by the current offer (in all areas) and intended for the direct manufacturing implementation (in the form of new technologies, products or services)" (Molchanov, 2014).

The term is enough confusing since there are at least two main different viewpoints. The term “innovation” is simultaneously can be treated as “the resulting product” and as an “act”. The end-product implies a certain result, so-called invention, and the act is used to describe the whole innovation process. For example, Brower classification includes two types: product and process innovations (Brouwer, 1991). Other scholars combine product and process innovations into technological innovations and distinguish them from non-technological innovation including marketing and organizational innovations (Jaskyte, 2011). Currently, all these innovation types are discussed in details in the Oslo Manual Guideline, provided by the Organization for Economic Cooperation and Development (OECD). Further, we are going to approach this definition in terms of the resulting invention and attribute the innovation process itself to the innovation activity.

Since innovation is the outcome of innovation activity it is necessary to overview possible approaches to this term. Academic literature suggests several interpretations of the “innovation activity”. Some experts pay attention to the creative part of innovation process, some of them focus on its production component, others pay greater attention to the customer habits and preferences. According to the Federal Act on “Science and state scientific and technical policy”, “innovation activity is a scientific, technological, organizational, financial and commercial activity aimed at the execution of innovative projects as well as the establishment of innovation infrastructure and the following support of its operation” (Federal Act N 127-FZ). Oslo Manual Guide provides us with the following definition: “Innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations.” (OECD/Eurostat, 2005). Moreover they claim that activities can be novel by themselves as well as they can represent some traditional activities that become a key driver for the deployment of innovation. However, they also consider R&D investment as an innovation activity even if it is not related to any specific innovation project.

Innovation activity in the current context is an indispensable condition for the maintaining and strengthening the enterprise position on the market. It is based on many various ideas - from simple ones, the implementation of which does not require significant expenditures, to global ones, based on the results of research and development that cannot be realized without major investment.

1.3. Relationship between innovation activity and performance of the company: related studies

Plenty of studies investigate and prove the effect of innovativeness on the company value and performance. There are at least two alternative points of view explaining the link between innovation and business performance. First, new product and processes enhance a company's competitive position comparing to its rivals. However, firm's profits and growth can be short-term and last as long as the company can defend its leading position against competitors. Another view states that the innovation process itself strengthen internal capabilities and make companies more flexible and adaptable to many external pressures and instability (Geroski, 1994).

The link between innovation activity and value is empirically proved. Browyn B. Hall has found a positive correlation between knowledge assets and firm market value. He investigated the effect of three variables: R&D expenditures, patents and citation-weighted patents. The results have shown that although patent coefficient is more informative than research and development investment, the correlation with market value is much weaker. In addition, weighted patents is more accurate indicator in comparison with patents (Hall, 1999). Another approach to the measure of the innovation activity influence on the firm value was suggested by Kraft and Czarnitzki. They have used similar indicators of innovation activity – R&D investment, the patent stock and sales of new products and examined its relation with the credit ratings change. As a result, in all cases they have discovered the significant influence of all innovation measures on the firm credit rating. However, the relationship was non-linear: if in some cases innovativeness led to the increase of the rating, in other cases innovation activities caused a negative effect (Kraft and Czarnitzki, 2002). Other scholars focusing on a sample of highly innovative Korean small and medium sized enterprises have revealed that the innovative SMEs tend to maintain higher firm value than non-innovative firms (Shin and Kim, 2011). Alina B. Sorescu and Jelena Spanjol examine the effect of radical innovations on the firm performance in terms of normal profits, economic rents and total risk. The breakthrough innovation development leads to the increase of profits and economic rents and respectively firm value. Although breakthrough innovation are also assimilated to higher risk, this increase is compensated by higher stock returns (Sorescu and Spanjol, 2008). The other research conducted by M. Annavarjula, R. Mohan and S. Beldona confirm the positive R&D spending effect on firm value immediately and over time as the estimates were positive and significant with one year and three year time lag. Concerning to the number patents, the proxy is significant only for three year lag that imply the impact of the patent application on a firm value after a certain time (Annavarjula, Mohan and Beldona, 2008). Therefore, in the majority of studies we can find a justification of positive relationship between innovation activities and the firm value. However, the linearity of relationship and significance of correlation in all the cases still depends on different factors including the time lag, data sample, and choice of appropriate variables.

First of all, the relationship directly depends on the innovativeness of the industry in general. The OECD provides the classification of economic sectors based on the level of technology intensity. This level for the particular industry is defined by the R&D spending for the considered sector divided by the total industry turnover. Four groups were allocated: high, medium-high and, medium-low and low technology industries. (OECD, 2013) The low-tech sector consist of industries offering products that are mostly based on so-called "mature" technologies - in contrast to "new" technologies in high-tech. The low-tech sector continues to be the basis of the economy and the fact that in conditions of innovative economy these industries are still competitive shows that some innovation activity is conducted. It becomes clear that innovations in low-tech and high-tech sectors have a number of differences important to take into account in our analysis. These differences mainly result from the fact that in low-tech internal R&D are supported by insignificant amount of investment and in high-tech this becomes a core element of innovation.

According to the Strategy& report on Global Innovation 1000, Computing and Electronics, Healthcare and Auto industries are the leaders on the R&D intensity and have contributed 61,3% of R&D spending in 2017. Software and internet industry has the fastest year-over-year growth 16,1% in 2017 and is going to take the third place out of the biggest R&D spenders that can be clearly seen on the Figure 2. At the same time healthcare sector currently is the second fastest growth industry, which is expected to outperform the computing and electronics sector and become the biggest R&D spender in 2018 (Strategy&, 2017).

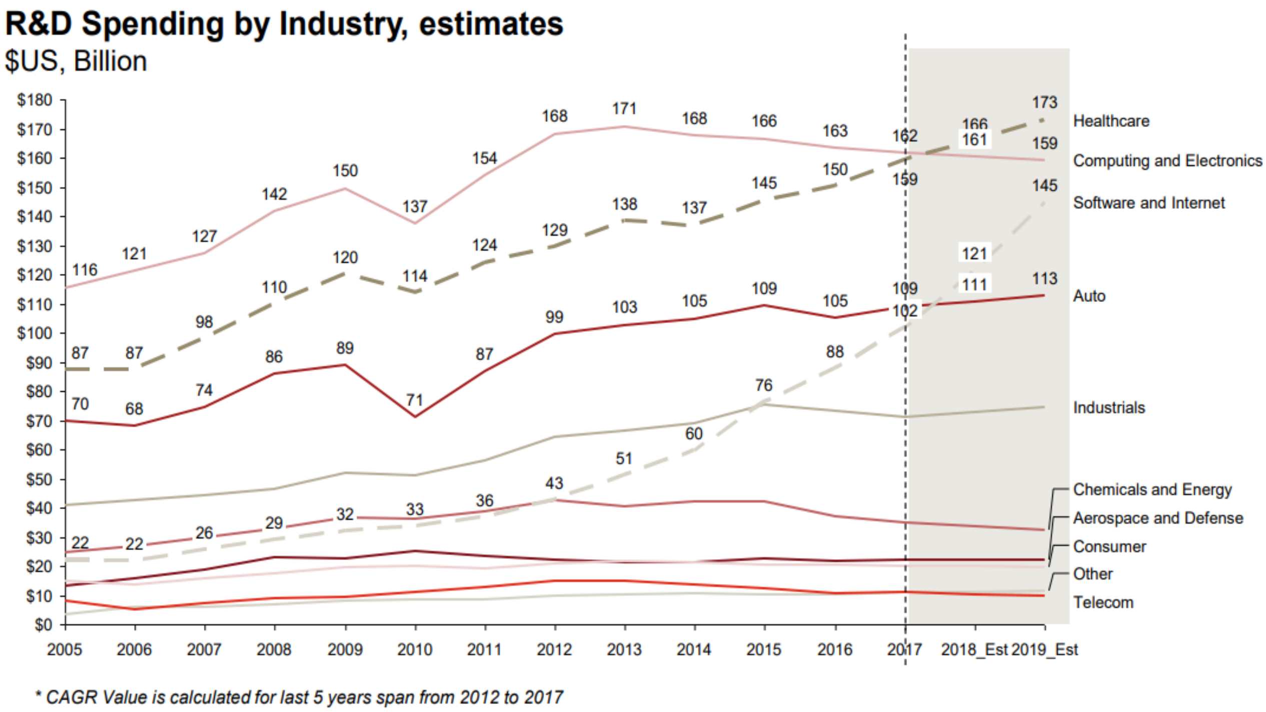

Figure 2. R&D spending by industry. (Strategy&, 2017).

According to Russian national ranking of rapidly growing technological companies, the most innovative industries by R&D spending are materials (33%) machinery and equipment, (26%), biotechnology and pharmaceuticals (20%) (TechUspeh, 2016). Hence, we see it relevant to focus on these sectors as high-technological industries. It is worth noting that according to the Strategy& study the efficiency of research and development activities in large companies of developed countries is decreasing (Jaruzelski, Loehr and Holman, 2011). Therefore, we consider the study that determines whether such an activity is effective in Russian conditions as in the developing economy meaningful.

1.4. Measurement of innovation activity

Despite the fact that many research studies confirm the positive effect of innovation activity on the firm and overall business performance the measurement of innovation remains an essential issue among the scholars and practitioners. The main reason for this is the fact that the innovation is a multi-dimensional phenomenon. Some determinants are difficult in terms of data collecting and measurement, some of them are not quantifiable at all. Another problem is that innovations are heavily dependent on the context such as type of product, industry or stage of life cycle that leads to the difficulties in data comparability.

Further, we are going to review the most common measurement of innovation activity – R&D investment, patent counts, patent citation counts, new product announcement, sales of innovation products, trademarks and intangible assets.

R&D investment is the most used metric for innovation activity and plenty of researches look at the company innovativeness exactly from the R&D expenses prospective. The main advantage of this metric is availability of the relevant data. "Being available since the 1950s, R&D figures still are the most popular innovation indicator" (Kleinknecht, Montfort and Brouwer, 2002). In addition, major importance is attached to the developed R&D measurement standards worldwide. In 1963, the "Proposed Standard Practice for Surveys of Research and Development" better known as Frascati Manual was published and over the last 50 years has grown to the international standard for statistical purposes. They define R&D expenditures are "all current expenditures plus gross fixed capital expenditures for R&D performed within a statistical unit during a specific reference period, whatever the source of funds" (OECD, 2015). UNESCO Institute of Statistic points out some limitation of the Manual application for non-OECD countries and extends these standards to review of challenges that developing countries can face (UNESCO, 2014).

Most empirical researches confirm the positive impact of research and development expenditures on the firm performance and its market value. Hence, R&D investment is no longer treated a cost, but rather increasing value expenditures. Thus, T. Koller, M. Goedhart and D. Wessels drawing attention to the importance of focusing on the long-term shareholders value and find a strong positive correlation between total returns to shareholders and R&D expenses in American companies (Koller, Goedhart, and Wessels, 2015). The dependence of TRS and R&D investment is shown in the Figure 3:

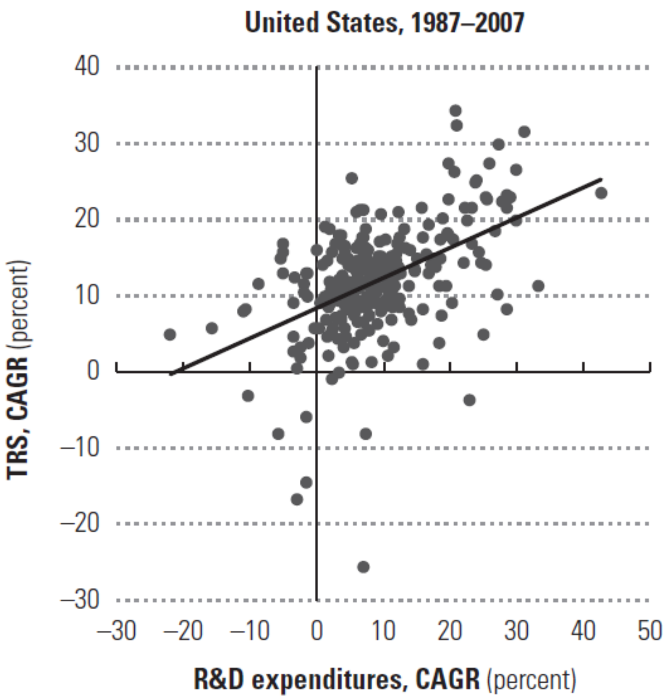

Figure 3. The correlation between TSR and R&D spending. (Koller, Goedhart and Wessels 2010).

Chauvin and Hirshey also verify the large positive influence of R&D expenses on the market value of the firm on a sample of .Compustat firms (Chauvin and Hirschey, 1993). S.C. Bae and D. Kim find this evidence incomplete since the studies are limited to only U.S. companies. Then, they broaden their research to Germany and Japan and argue that it is warranted for several reasons. Firstly, Japan and Germany along with the USA were the leading countries by R&D investment and could be a threat to the USA competiveness for the observed period. Secondly, researchers claim some distinctiveness in the research and development activities of considered countries that could lead to the different outcome (Bae and Kim, 2003). Consequently authors prove their hypothesis about significant positive effect of R&D investment on the market value across all three nations (Bae and Kim, 2003). Some researches are dedicated to announcement of R&D investment. The research of R&D expenditures and the firm value relationship on English countries conducted by Toivanen consider the R&D investment as an innovative driver and reveal that the its effect is positive and depends on the firm's market share. The bigger market presence, the bigger the impact of R&D expense (Toivanen, Stoneman and Bosworth, 2002). Doukas and Switzer even presented the evidence of the R&D spending announcement influence on the share price reaction that also lead to conclusion of the positive correlation between innovation activity and market value of the company (Doukas and Switzer, 1992).

Some authors focus on the investigation of non-linear relationship between company's performance and its R&D activities. In the study (Pantagakis, Terzakis, Arvanitis, 2012), authors formulate the hypotheses about a positive relationship between R&D intensity and financial performance of the company. This hypothesis is based on the assumption that innovations become a competitive advantage of the enterprise that leads to the increase of profit and cost reduction that can significantly increase the value of a firm. However, they query the linear nature of this relationship and additionally test the hypothesis about the non-linear relationship between R&D intensity and the market value of companies. As a result, the authors have found that the optimal amount of R&D investment that allows achieving the maximum increase of market value is 41% out of revenue. Other researcher (Beld, 2014) have find the significant non-linear relationship not only for market-based performance, but also for accounting-based performance, measured as ROA. Moreover, companies were divided into production and service sectors based on the assumption that R&D activities are more important for the manufacturing sector. In result of the research implying a non-linear relationship between the intensity of R&D expenditures and the company's performance, it was found that the optimal amount of R&D investments is 12% of the revenue per year (for the entire sample of companies).

However, this indicator still has some limitations. Research and development expenditures measure just one part of overall innovative activity in the company. Likewise, some companies deploy innovations, but do not report the relevant expenses. In the opposite case, the R&D spending is only the input of the whole innovation process that can have different levels of efficiency. Therefore, it becomes difficult to measure the innovative activity by only this indicator. A. Geroski states that “R&D is not obviously an essential input into the production of innovations: plenty of firms have introduced major or minor innovations despite the lack of a formal R&D lab or a specific accounting of R&D expenditures.” (Diederen and Geroski, 1996). Another issue is the effectiveness of the R&D costs. Empirical research of the Strategy& demonstrate that there is no direct link between expenditures on R&D and main financial performance indicator such as revenue and sales growth (Strategy&, 2017). Therefore, the intensity of R&D cost does not necessary represents the firm’s innovation activity and increase the shareholders wealth if the company does not use these investments effectively. Hence, it is also important to consider the output factors of innovation process.

Patent counts is also quite widespread indicator and used to demonstrate the output of innovation activity. Some researches provide an empirical evidence that number of patents is a reliable proxy for measurement of innovation activity (Acs, Anselin and Varga, 2002). Usually it is considered as the second best proxy and the main reason for this is the availability of data as well as with R&D efforts. It is widely used by many researches as it enables to compare the inventive or innovative performance of companies in terms of new technologies, new processes and new products (Hagedoorn and Cloodt, 2003).

However, there are drawbacks that reveal some imperfections of using this metric. It is obvious that this proxy does not cover not-patented inventions. Not all the scientific researches and innovations need to be registered as patents before entering the market (Burhan, Singh and Jain, 2017). Another issue is that according to OECD not all inventions meet the required legal criteria for patenting or not patentable at all (OECD, 2009). In addition, the value and importance of patents can vary, so the number of patents cannot properly show the level of company innovativeness (Jaffe, Trajtenberg, 2002). Firstly, patents can be more valuable and representative in particular industries. For instance, the patenting is crucial for protection in chemical and pharmaceutical industry where the risk of imitation is much higher Burhan, Singh and Jain, 2017). Secondly, some patents can play a supportive role and represent insignificant improvements in economic value, while others can become enormously valuable for the whole business. Furthermore, we need to take into account the cases where patents serve as strategic, but not innovation activity. For instance, a company can register the patent to prevent competitors from using the patented technology, but it will not add value to the company (Kleinknecht, Montfort and Brouwer, (2002).

To sum up, number of patents alone is not able to reflect the whole picture of company innovation activity. Hall's research claims that "patent counts do not have as much explanatory power as R&D in a market value equation, but they do appear to add some information above and beyond R&D" (Hall, 1999).

Patents citation contains not only technological but also economically significant information that can be used to assess the quality of patents (Hall, Jaffe and Trajtenberg 2005). Some studies demonstrate that simple patent count by itself does not correlate with the company value, but citation-weighted patent count shows higher correlation (Hall, 1999). It provides empirical evidence that patent citation reflects the patent quality and better explains relationship with firm value.

However this indicator is also not perfect for the entire innovation activity and has some drawbacks. J. Bessen estimated the value of patents filed at the United States Patent and Trademark Office (USPTO) and came to conclusion that patent citation explains only about 6% of the patent value variance (Bessen, 2008). Therefore, the value of patent is based on more sophisticated factors and only citation count cannot explain its value. Another issue is the lag between patent registration and patent citation – the reliable patent citation information is accessible only in the later part of the considered sample.

New product announcements are also intended to demonstrate the output of innovation activity. The advantage of this metric lies in the fact that data is publicly available and does not require an access to private data sources. However, the problem can lay in the definition of comparability factors. A. Kleinknecht and K. Montfort suggest the solution for this problem by the dividing the data on appropriate dimension (innovation type, degree of complexity and others) (Kleinknecht, Montfort and Brouwer, 2002). Although this is hardly ever achieved in practice. Another possible drawback is that new product announcement by company are defined by themselves as the company interpret them that disrupt the credibility of these estimates.

Sales of innovative products are a straightforward measure of innovation success expressed as a positive cash flow. Firms asked to estimate the share of newly developed products in the last total sales. This category can include not only products or processes based on new technologies but also new novel application of already used technologies (Kleinknecht, Montfort and Brouwer, 2002). This metric is more presentative than others as it shows accurate market results. However, this indicator is highly depends on the stage of life-cycle that makes the estimates rough and overestimated. Moreover it becomes difficult to compare different products if they were implemented with a big difference in time.

Trademarks represent a quite new approach to measure innovation. According to OECD Science, Technology and Industry Scoreboard “use of trademarks allows firms to signal novelty and to appropriate the benefits of their innovations when they launch new products on the market” (OECD,2013). The study reveals a strong correlation between the number of trademark application and other innovation indicators: they are able to impart information on product, marketing or services innovations. The availability of the data right after filling the application allows collecting information on innovation activities immediately. S. Mendoca, T. Pereira and M. Godinho tested trademarks as an as an output indicator of innovative activity and have found the positive correlation between trademark registration and technological and informational intensity in both manufacturing and service industries (Mendonça, Pereira and Godinho, 2004). Further, M. Gotch and C. Hipp criticize the traditional measurement concept and apply the trademark analysis on the measurement of innovations in the knowledge-intensive business services (KIBS). Consequently, they overcome issues related to the immateriality of services (Gotsch and Hipp, 2012).

Considering all the possible indicators above, I. Berzkalne and E. Zelgalve suggest the *intangible assets* as a proxy for innovation activity. They claim that even if R&D efforts are not a part of intangible assets, it will result in the implementing of some patented or copyrighted innovative product. This, in turn, will be indicated in the balance sheet as intangible assets (Berzkalne and Zelgalve, 2014). Statement of Financial Accounting Standards (SFAS) include in intangible assets the four following components: 1) R&D costs; 2) software development; 3) patents and copyrights; 4) brands and trademarks (FASB, 2010). Although there are many authors who examined and proved intangible assets correlation with the value and performance of the company, the link between innovation activity of the company and its intangible assets reported is questionable. In our opinion this indicator is enough controversial and the results of such an analysis are expected to be roughly approximate. Therefore, using of this metric requires a careful analysis of the sample before applying it.

We see it useful to summarize the strength and weaknesses of all indicators considered above (See the Table 1).

Table 1. Innovation measures comparison.

Metrics	**Advantages**	**Disadvantages**
R&D intensity	Availability of the relevant data; Existence of R&D measurement standards; The applicability is proved by many researches	Input nature of R&D does not ensure the efficiency of output; The R&D investment are not always reported; Consider only a part of innovation input
Patent counts	Availability of the relevant data; Demonstrate the output of innovation activity	Not all the inventions are patented; High variance of patent value and importance; Patents can be a result of strategic behavior
Patent citation	Demonstrate the output of innovation activity; Address the problem of patent quality measurement	Explain only a part of patent's value; lag between patent registration and patent citation
New product announcement	Demonstrate the output of innovation activity; Publicly available data; It is possible to divide data on appropriate dimensions	Difficulties with the determination of eligible dimensions; There is no standard for definition of the product novelty
Sales of innovation products	Straightforward indicator with measurable effect	Dependent on the product life-cycle
Trademarks	Availability of the relevant data; Address the problem of appropriate metrics in service industry	Limited to the service industry; No information on application on the manufacturing industries
Intangible assets	Availability of the data in the balance sheet; Data is standardized	Accounting data may be not correct and prepared for the accounting purposes

Source: created by author.

Therefore, having considered the most commonly applied innovation activity indicators, their advantages and disadvantages, we have reached the conclusion that a particular metric or methodology that can be applied to all the cases successfully does not exist. All the indicators intended to measure and analyze innovations are usually based on approximate calculations and appropriate assumptions. J. Hagedoorn and M. Cloodt try to measure innovation performance applying multiple indicators – R&D inputs, patent counts, patent citations and new product announcements. The research suggests that a composite construct based on these four indicators clearly catches a latent variable "innovative performance". However, authors also claim that statistical overlap between examined indicators is that strong that future research might also consider using any of these indicators to measure the innovative performance of companies in high-tech industries (Hagedoorn and Cloodt, 2003). A. Grinevich, V. Kitson, and M. Savona state that complexity and variability of the innovation process means that new and different indicators will be appropriate in different sectors of the economy, though the sector comparison becomes more complicated (Abreu et al., 2011). .

1.5. Factors affecting firm's R&D expenditures

Most studies we reviewed previously are concentrated on the revealing of relationship between precisely R&D expenditures as an innovation activity and firm's performance. To analyze the specific of such a relationship deeper and provide some meaningful managerial implications it is also necessary to consider factors that can influence the R&D investment decision.

Usually authors analyze two types of factors:

1) *External factors* that does not depend on the enterprise activities such as the industrial features and its structure, government policies and market conditions.

The external factors include market factors (diversification of firms' activities, competitiveness of the industry, the external economic relationship conditions, changes of tariffs and prices as a result of inflation) and legal and administrative factors (taxation, acts and regulations governing the activity of organizations, state regulation of prices and tariffs).

There are many researches dedicated to the investigation of the external factors influencing the firm's innovation behavior. The empirical research of Y. Wang, Y. Wei and F. Song is considering effects of both policy and market uncertainties and find a negative correlation between these factors and R&D investment decisions (Wang, Wei and Song, 2017). J. Vega-Jurado, A. Gutiérrez-Gracia, I. Fernández-de-Lucio and L. Manjarrés-Henríquez select technological opportunities and appropriability conditions as factors influencing R&D investment decision and find that this influence strongly depends on industrial sector (Vega-Jurado et al., 2008). X. Shi and Y Wu examine the effect of both internal and external factors on the firm's innovation activity. Their analysis of external factors is based on the theory of regional innovation system that implies that innovation activities are not isolated actions within the single firm, but the collective accomplishment of several entrepreneurs. Hence, they investigated the intense of firm's innovation activities embedded in particular regions and considered the effect of following external factors: competition intensity, volume of foreign direct investment, financial development of regions, environmental protection policies, government support, regional GDP per capita and density of innovation unities including universities and enterprises (Shi and Wu, 2017).

2) *Internal factors* that directly depend on the firm's activities and managerial decisions.

Many studies are also devoted to the investigation of relationship between R&D and usually relies on resource-based view (RBV) which pays attention to the firm's heterogeneity and the role of internal characteristics in business strategy (Wernerfelt, 1984). According to this view, every firm has its own and unique set of resources and capacities, which evolve and develop over time. Consequently, these exceptional resources and capacities determine the further degree of firm's efficiency and, thus, the managerial decision including the decision related to innovation activities. They are usually split on financial, physical and intangible resources (see the Figure 4):

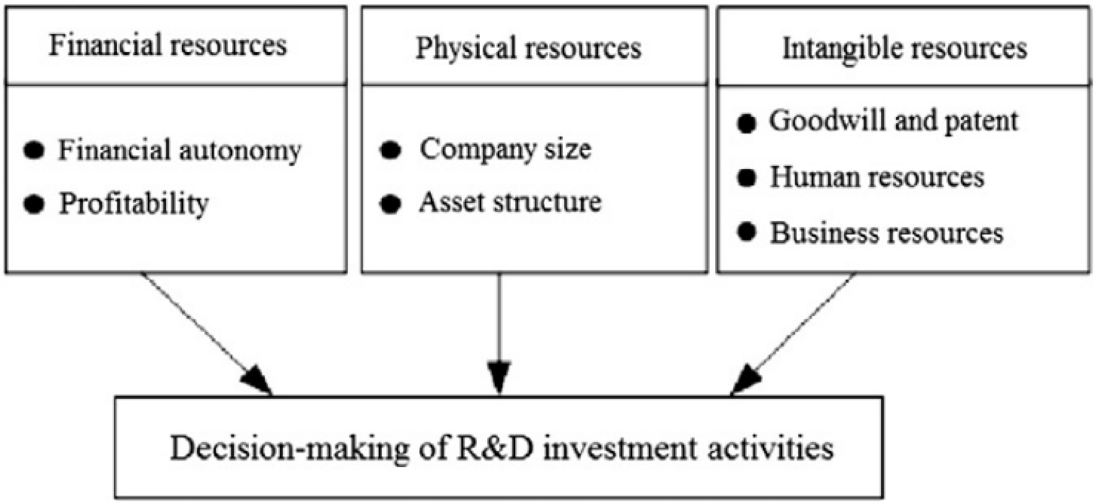

Figure 4. The resource-based framework. (Lai, Lin and Lin, 2015).

Furthermore, Y. Lai and F. Lin draw attention to the fact that the investigation of internal decision factors is crucial comparing to external factors because in most of the cases they can be controlled and influenced my management decision-making (Lai, Lin and Lin, 2015). Authors of research (Galende and de la Fuente, 2003) also consider internal factors and apply the resource-based view approach as a fundamental one. To sum up, the analysis of the internal environment makes it possible to determine the opportunities of company that can be used in order to compete in the market and to obtain a sustainable competitive advantage. Further, we will focus on the internal factors and their influence on the R&D investment from the resource-based prospective.

Financial resources focus on the financial situation of the company, its availabilities to repay debt and generate profit. The metrics such as financial autonomy and profitability are vital for both short-term and long-term development and can easily affect the decisions of the top management on any investment decisions. Since these factors have tangible nature, they can be easily collected and measured that have led to their broaden use in a great variety of studies. Y. Lai and F. Lin confirm the hypothesis that higher corporate financial autonomy will more effectively encourage investment in R&D activities, measuring financial autonomy as asset-liability's ratio (Lai and Lin, 2014). Another explanation of this negative relationship is related to the uncertainty of the innovation nature: high risks associated with innovation activities can cause some problems with debt financing. Significant number of researches (Giudici and Paleari, 2000; Galende and de la Fuente, 2003) point the negative relationship between debt burden and innovation activities. Another hypothesis that authors usually consider is related to the relationship between profitability indicators and investing in R&D. Authors (Coad and Rao, 2010) point that this is an important determinant of the R&D investment decisions due to the riskiness of innovation activities. Companies need high revenues and profits to support R&D investment and to minimize risks related to R&D. Based on these Y. Lai and F. Lin reveal that higher firms' profitability (ROA) result in more active R&D investment activities (Lai and Lin, 2014).

Physical resources include size and asset structure of the firm. Large amount of researchers investigate the relationship between firm's size intensity of R&D activities and the empirical results varies greatly. There are arguments for both perspectives. Larger firms can be more innovative due to the smaller risks they face, better appropriation possibilities. Moreover, larger firms are usually more powerful in the marketplace that would encourage innovation activities. At the same time smaller firm are more flexible, have better communication and specialization possibilities to implement innovations. According to Schumpeter's theory, larger firms tend to be more innovative than smaller ones (Schumpeter and Opie, 1961). Other authors (Fishman and Rob, 1999) claim that large companies in most cases have better management capabilities than smaller ones and as a result larger R&D expenditures. Some scientists consider not only asset size, but also sales amount and the number of employees as a proxy for company's size and find that their increase leads to the increase of R&D expenditures (Park, Shin and Kim, 2010).

When analyzing companies' physical resources it is also important to take into account its assets structure that include buildings, equipment and production facilities that firm use and their importance with respect to the rest. Conducting R&D activities requires a minimal preliminary investment in the technological equipment that lead to increase of capital intensity. On the other hand, the results of R&D activities are expressed in highly valuable fixed assets added to the company's manufacturing system. Many scholars examine the interrelation of company's capital structure and R&D expenditures (Dalziel, Gentry, & Bowerman, 2011; Del Canto and González, 1999). Lai and Lin claim that the more valuable enterprise's tangible resources are more conductive to the increase of technological investment, therefore they argue that A higher dependence on tangible assets such as use of fixed assets (depreciation) leads to a higher willingness to invest in R&D activities (Lai and Lin, 2014).

Intangible resources are the most questionable since their measurement is difficult. Therefore, the empirical studies on these factors are limited (Cohen, 1995). Nevertheless, its relationship with innovation activities can be even more significant than for tangible assets. The most common intangible factor is related to human resources. Fleming based on his empirical research suggests that firm's technical staff that have an expertise in technology areas can become a driver of R&D-related activities (Fleming, 2001). The qualification of personnel allows conducting more intensive and long-standing research work. Lai and Lin also accept the hypothesis that better enterprise human resources can lead to a higher engagement in R&D activities on the sample of leading East Asian countries (Lai and Lin, 2014). Other authors also find a positive relationship between the qualification of employees (measured as personnel expenditures) and innovation activity on the sample of European firms (Galende and de la Fuente, 2003).

Another group of intangible assets that is usually applied in the empirical studies investigating the factors affecting innovation activities includes goodwill, patents, trademarks and brands. In the study authors (Arora, Ceccagnoli, and Cohen, 2008) point out the significant and positive relation between R&D investment and successfully implemented patents. Others notice that better brand performance is linked to a higher innovation activity (Weerawardena, O'Cass, and Julian, 2006). Hence, the significance of this relationship is proved by the plenty of researches.

Some authors also consider business resources of the company that are mostly based on an enterprise's export activities. Accordingly, related empirical studies demonstrate the significant relationship between R&D activities and company's export activities (Lai and Lin, 2014; Park et al., 2010; Tomiura, 2007).

Summary

There are different approaches to assess the company's financial performance. Basically, these indicators can be divided into two major groups. Accounting-based performance is measured by the financial ratios of the company (ROA, ROS, ROE) and represent its efficiency in terms of ability to generate profit, liquidity, financial structure and use of resource. Market-based performance is represented by the market value of the company and expresses the firm's attractiveness to investors. It is usually measured as Tobin's Q ratio, market capitalization, total shareholder's return (TSR).

According to OECD, innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. These activities can be novel by themselves as well as they can represent some traditional activities that become a key driver for the deployment of innovation(OECD/Eurostat, 2005).

The relationship between innovation activities and company's financial performance is empirically proved. Despite the fact that many research studies confirm the positive effect of innovation activity on the firm and overall business performance the measurement of innovation remains an essential issue among the scholars and practitioners. The most common measurement of innovation activity are R&D investment, patent counts, patent citation counts, new product announcement, sales of innovation products, trademarks and intangible assets.

To analyze the specific of relationship between innovation activities and financial performance deeper many authors also focus on the factors that can influence the R&D investment decision. Internal factors that, in turn, are able to affect the R&D-related activities can be divided into financial, physical and intangible resources.

Chapter 2. Empirical study of relationship between innovation activity and financial performance of the company

In the previous chapter we conducted a literature review of Russian and foreign researches, statistical data on innovation activities of the companies across different industries and its measurement. In addition, we have considered the indicators that are usually applied to evaluate the company's financial performance. In this chapter, according to examined theoretical premises we are going to conduct a research aiming at identifying interaction between key innovation activities of the company and its performance as well as identifying factors that may affect R&D investment decisions. First of all, we formulated the main hypotheses of our research and methodology by which the hypotheses will be tested. Then we describe the sample on which the study is going to be conducted, the descriptive statistic of chosen variables.

2.1. Hypotheses statement

As we have already explored conducting a literature review there is a plenty of empirical evidences of the link between innovation activity and the company's performance. The majority of researchers, whose studies were described in the previous chapter, tend to conclude that most innovative activities of company (for example, R&D investment, patents and trademarks registration and launching of new products or services) make a tangible effect on the generating of positive performance results.

As a measurement of innovation activities we are going to consider two items – results of R&D and the number of patents registered during the considered year. Both these metrics were chosen, as they are the most reliable proxies proven by the previous researches. One more reason is that the data is available in the databases and companies' reports.

R&D expenditures is the most common metric in the previous researches that indicate the existing of strong positive correlation between firm's R&D investment and its performance. The more detailed discussion on the use of this metric as an innovation activity indicator was provided in the Chapter 1. In addition, investigation of such relationship on the sample of Russian companies eliminate the drawback of the input nature of R&D investment existing in the previous papers. This advantage follows from the peculiarities of Russian accounting standards. According to the Russian regulation on accounting, R&D expenditures is a distinct accounting object. The information on R&D expenditures is reported on the balance sheet in intangible assets account. Furthermore, it is stated as "Results of research and development" and implies the cost of completed work (PBU 17/02, 2002). There is no analogical item in the international standard of financial statements. According to the Russian accounting standards on the cost recognition, research and development activities that in order to be reported have to meet the following requirements (PBU 17/02, 2002):

1) The cost of activities has to be preciesely defined and confirmed;
2) The cost of activities has to be officially confirmed and documented;
3) The research and development activities has to be aimed at maximizing of the company's profit and creation of favourable conditions for the gaining profit in the long-term perspective;
4) The results of research and development activities can be visually demonstrated.

This specification of R&D investment in the Russian accounting allows us to focus only on successful and deployed results of R&D. Hovewer, the legislation rules are not clearly stated and there arise questions on correct reporting of this account. V. Sitnikova reveals some gaps in Russian accounting policy concerning to R&D results recognition. Author notes that currently two following options of R&D results valuation found the practical use (Sitnikova, 2017):

1) All aggregated actual cost associated with sucessful R&D results
2) Only the part of costs incurred by the company from the moment of emergence of confidence in the positive R&D result.

To identify the impact of R&D investment on company's performance during it is crucial to take into account the time it takes between them. In the case of overall R&D expenditures scientifics prove a significant positive relation between two-year lagged R&D investment and firm performance (Bae, Kim, 2003). In comparison to the overall R&D expenditures the time of the R&D results effect can be different. Hovewer, we suppose that the effect of implemented results of R&D can also develop and correlate with the future performance. Therefore we see it reasonable to consider also the lagged effect. The data is available only for 2011-2016 year, therefore we will investigate the relation of one-year lagged R&D results and the firm's performance.

As we have already considered in the literature review, the number of registered patents is also the reliable proxy for innovation activities used by many scientists. Even if patent counts have some limitations, they may add some explanation above and beyond R&D. On the base of previous researches we are going to evaluate the two-year lagged patent counts (Bae, Kim, 2003).

The main research question is formolated as follow: "Whether the innovation activity is related to the firm's financial performance?" Accordingly we derive the following **hypotheses**:

Hypothesis 1. There is a ***non-linear correlation*** *between results of research and development and financial performance in Russian public companies.*

Hypothesis 2. There is a ***positive correlation*** *between the number of patents and financial performance in Russian public companies.*

Having considered a number of studies addressing the effects of innovation activity, we have noticed that the use of both market-based and accounting-based performance indicators is widespread. Among the accounting indicators the most common metric is return on assets (ROA). This indicator reflects the operational performance of the company and is going to be used in the following research computed as operational profit scaled by total assets.

The other indicator which is also prevalent in the previous studies is Tobin's Q that is a market-based metric. We see it feasible to use this metric as a dependent variable. The choice was based on the fact that, firstly, the market indicators of financial performance best reflect the impact of innovation activities within the company, as they are directly related to the market reaction on the firm's development announcement. The literature review on relationship between innovation activity and performance has also shown that the most common market indicator is precisely the Tobin's Q ratio. The value of this indicator will be determined as market capitalization plus book value of debt scaled by book value of total assets.

Therefore, in this paper we are going to evaluate both the market-based and accounting-based performance of the firms and their interdependence with companies' innovation activity.

Moreover, we find it reasonable also explore factors that may affect the company's decision to innovate. Based on the literature review on this issue that is presented in the Chapter 1, we have stated the following hypotheses:

Hypothesis 3. There is a ***positive correlation*** *between size of the company and its results of research and development.*

Hypothesis 4. There is a ***positive correlation*** *between the quality of human resources and its results of research and development.*

Hypothesis 5. There is a ***positive correlation*** *between the firm's capital intensity and its results of research and development.*

Hypothesis 6. There is a ***negative correlation*** *between the firm's leverage and its results of research and development.*

2.2. Methodology

The empirical research consist of two parts. The first part was conducted in order to confirm the hypotheses about the relationship between innovation activities (R&D result and patents) and financial performance of the company. According to previously stated hypotheses and chosen indicators of financial performance, two of the models describe the relationship between innovation activity factors and Tobin's Q ratio (market-based performance):

$$TQ_{it} = \beta_0 + \beta_1 * RD_{i,t-1} + \beta_2 * RD^2{}_{i,t-1} + \beta_3 * REV_{i,t} + \beta_4 * LEV_{i,t} + \beta_5 * oil_{i,t} + \beta_6 * energy_{i,t} + \beta_7 * metall_{i,t} + u_{i,t} \quad (7)$$

$$TQ_{it} = \beta_0 + \beta_1 * PAT_{i,t-2} + \beta_2 * REV_{i,t} + \beta_3 * LEV_{i,t} + \beta_4 * oil_{i,t} + \beta_5 * energy_{i,t} + \beta_6 * metall_{i,t} + u_{i,t} \quad (8)$$

The other two model describes the relationship between innovation activity factors and ROA (accounting-based performance):

$$ROA_{it} = \beta_0 + \beta_1 * RD_{i,t-1} + \beta_2 * RD^2{}_{i,t-1} + \beta_3 * REV_{i,t} + \beta_4 * LEV_{i,t} + \beta_5 * oil_{i,t} + \beta_6 * energy_{i,t} + \beta_7 * metall_{i,t} + u_{i,t} \quad (9)$$

$$ROA_{it} = \beta_0 + \beta_1 * PAT_{i,t-2} + \beta_2 * REV_{i,t} + \beta_3 * LEV_{i,t} + \beta_4 * oil_{i,t} + \beta_5 * energy_{i,t} + \beta_6 * metall_{i,t} + u_{i,t} \quad (10)$$

Variables $TQ_{i,t}$ and *ROAi,t* are the dependent variables reflecting company's financial performance. *RDi,t-1*, *RD2i,t-*$_1$ and *PATi,t-2* are the factors representing the company's innovation activity. *REVi,t* and *LEVi,t* stand for control variables and according to majority of researches characterize the financial performance of the company. $U_{i.t}$ is a random error. All the variables have the indexes *i* and *t* that demonstrate the panel data analysis, where the information is provided and measured for every company *t* at the specific moment in time *i*. Variables *RDi,t-1*, *RD2i,t-*$_1$ and *PATi,t-2* have the indexes *i,t-1* and *i,t-2* that indicates the time lag between R&D investment and the indicators of financial performance as well as control variables. β_0, β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8 – unknown coefficients. The description of used variables is presented in the Table 2.

Table 2. Description of variables used in the models

Variable	**Description**
Dependent variables	
$TQ_{i,t}$	Tobin's Q ratio – the indicator describing the financial performance of company and computed as following: $\text{Tobin's Q} = \frac{\text{MV} + \text{BVdebt}}{\text{BVsssets}}$ where MV – market capitalization BVdebt – book value of debt BVassets – book value of assets

Variable	Description
$ROA_{i,t}$	Return on assets – variable, describing operational performance of companies and computed as following: $$ROA = \frac{\text{Operating profit}}{\text{Total assets}}$$
Independent variables	
$RD_{i,t-1}$	Variable representing the innovation activity that is equal to the natural logarithm of research and development results considered with one-year lag
$RD^2_{i,t-1}$	Variable representing the innovation activity that is equal to the square of the natural logarithm of research and development results considered with one-year lag
$PAT_{i,t-2}$	Variable representing the innovation activity calculated as the number of patent registered with two-year lag
$oil_{i,t}$	Dummy variable, indicating whether the company is related to the oil&gas sector
$energy_{i,t}$	Dummy variable, indicating whether the company is related to the energy sector
$metall_{i,t}$	Dummy variable, indicating whether the company is related to the metallurgy sector
Control variables	
$REV_{i,t}$	Variable that reflects the size of the company and is equal to the natural logarithm of company's revenue
$LEV_{i,t}$	Variable that that stands for the leverage situation and is computed as follows: $$Leverage = \frac{Total\ Debt}{Total\ Assets}$$

Source: created by author

The second part of empirical study is dedicated to investigation that factor may affect the company's innovation activity decisions.

$$RD_{it} = \beta_0 + \beta_1 * SIZE_{i,t} + \beta_2 * HR_{i,t} + \beta_3 * CAPINT_{i,t} + \beta_4 * LEV_{i,t} + \mathrm{u}_{i,t} \quad (11)$$

In equation (11), the amount of R&D results for the current uear was chosen as a dependent variable. The independent variables were chosen on the base hypotheses that were previously stated. The detailed description of used variables is provided in the Table 3.

Table 3. Description of variables used in the models

Variable	**Description**
Dependent variables	
$RD_{i,t}$	Variable representing the innovation activity that is equal to the natural logarithm of research and development results
Independent variables	
$SIZE_{i,t}$	Variable that reflects the size of the company and is equal to the natural logarithm of company's revenue
$HR_{i,t}$	Variable representing the quality of human resources and computed as following: $Human\ Resources = \frac{Labor\ expences}{Revenue}$
$CAPINT_{i,t}$	Variable representing the company's capital intensity calculated as following: $Capital\ Intensity = \frac{Depreciation\ cost}{Revenue}$
$LEV_{i,t}$	Variable that that stands for the leverage situation and is computed as follows: $Leverage = \frac{Total\ Debt}{Total\ Assets}$

Source: created by author

Right after the formulation of methodology we proceeded to the data collection and analyzing process.

2.3. Data and descriptive statistics

The econometric analysis implies the application of findings to the whole population. Consequently, to get statistically significant results, the selected sample has to meet the representativeness condition.

In Russian legislation all the joint-stock companies are divided into public and non-public (Civil Code of the Russian Federation, 1994). Public companies can attract equity through the public offering of shares both in the stock exchange (in Russia it is the MICEX) or in the OTC markets. For the listing of shares on the exchange, the companies have to meet the specific stock exchange requirements. One of them is the obligation of detailed disclosure of corporate information. Therefore, the following sample consist of Russian public companies whose shares are traded on the MICEX during the year before the date the survey was conducted. Furthermore, selected companies have to provide all the necessary information for research: the companies have reported R&D results and patents for the considered 5 years. The preliminary sample consists of 45 Russian companies for the 5-year period from 2012 to 2016. The complete list of the companies is provided in the Appendix 1. The data on number of patents was collected for 2010-2014 year, for R&D results – from 2011 to 2015 year. We choice of precisely this period stems from the fact at the moment of conducting research that many companies have not yet published the annual reports for 2017.

For the following study two types of data were collected: financial data for calculation of firm's performance and data related to the firm's innovation activity. The following sources were used to gather statistic data:

1) SPARK, SKRIN databases
2) Official annual and quarterly financial statement of the considered companies\

After removal of outlier in the sample 218 observations have remained for the models investigating relationship between innovation activity and financial performance and 212 observations for the models investigating relationship between R&D results and company's internal resources.

The choice of industries were based on availability of data, representative amount of companies within the industry and the highest rate of R&D spending by industry according to the national ranking of rapidly growing technological companies "TechUspeh-2016". Consequently, the sample consist of oil and gas industry, energy industry, machinery and equipment manufacturing and metallurgy. Due to the specifics of Russian business, the majority of selected companies, which is 37%, belong to the energy sector (production, transmission and sale of electricity), 27% relates to the metallurgy industry, 24% - to the oil and gas industry and 13% is taken by the machinery and equipment manufacturing sector (see Figure 5).

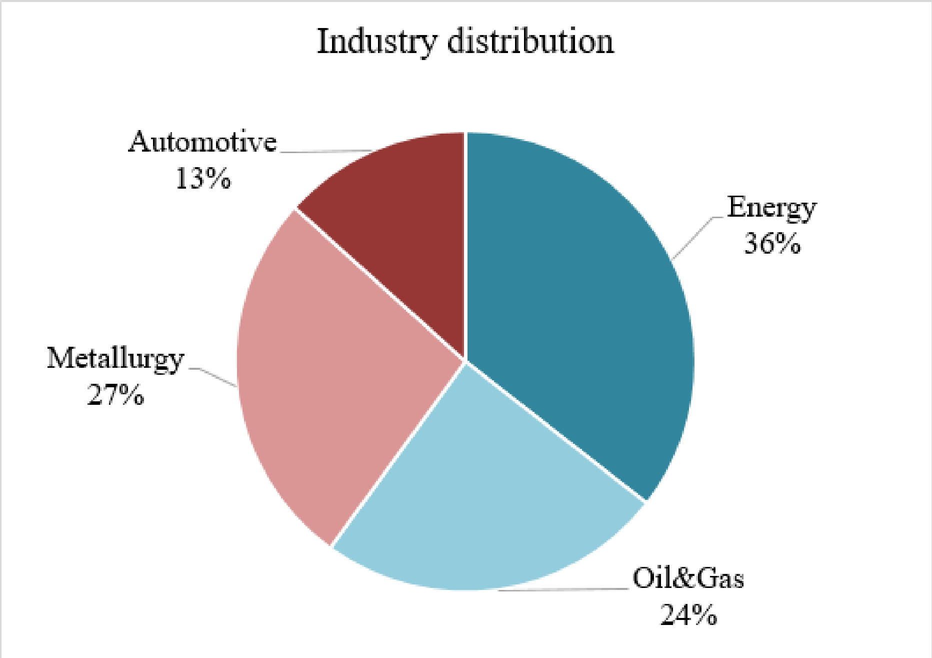

Figure 5: Industry distribution of the sample. (Author's analysis).

The descriptive statistic variables of used in analysis is provided below in order to provide the reader with a comprehensive overview of the data (see the Tables 4, 5). It is also presented in the Appendixes 2, 3.

Table 4. Descriptive statistics of variables of the 1-4 models.

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
ROA	212	0.106	0.137	-0.291	0.547
TQ	212	0.91	0.4977392	0.1462306	2.567
RD	212	391 000 000	1 340 000 000	450000	12 700 000 000
PAT	212	18.571	44.625	1	262
LEV	212	0.553	0.349	0.030271	1.776
REV	212	320 000 000 000	805 000 000 000	1 300 000 000	4 330 000 000 000

Source: created by author

Table 5. Descriptive statistics of variables of the 5 model.

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
RD	202	434 000 000	133 000 000	450 000	10 500 000 000
SIZE	202	350 000 000 000	836 000 000 000	1 300 000 000	4 330 000 000 000
HR	202	0.112	0.091	0.000	0.622
CAPINT	202	0.088	0.479	0.001	0.257
LEV	202	0.582	0.477	0.031	3.938

Source: created by author

We have analyzed the distribution of R&D results by industry and have found that the most innovative industry is machinery and equipment manufacturing. This sector significantly outperforms others and in 2015 achieved 2.2 billion RUB when energy, oil and gas and metallurgy industry does not exceed 1 billion RUB (Figure 6).

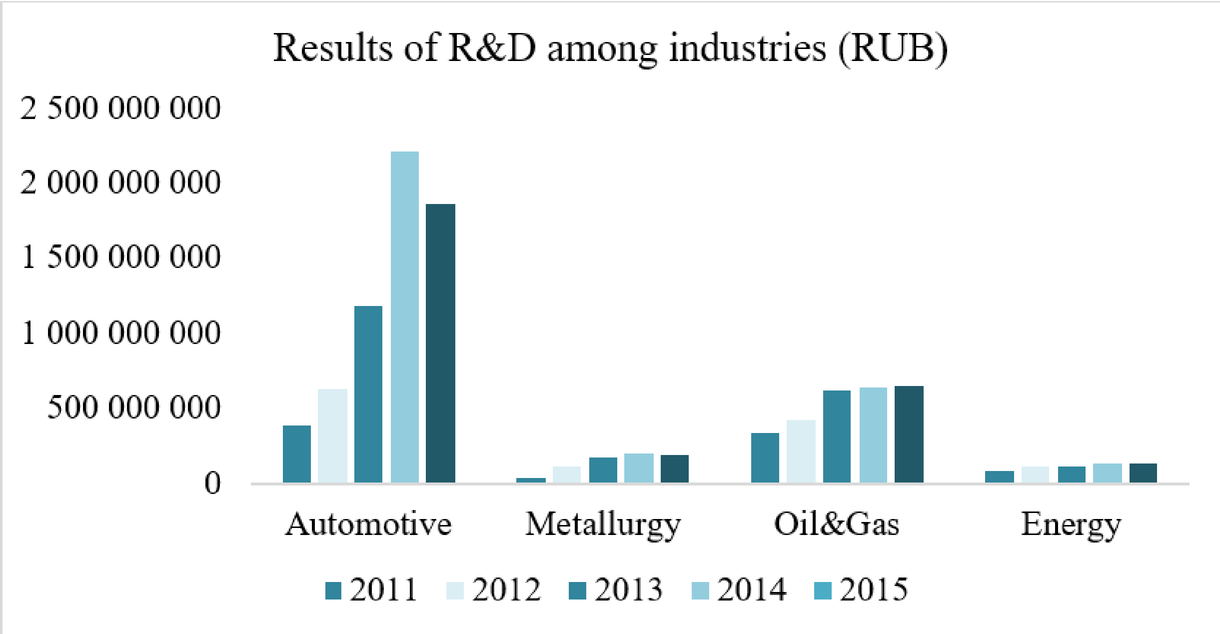

Figure 6: Results of R&D among industries (RUB). (Author's analysis).

This finding proves the research provided by the national ranking of rapidly growing technological companies "TechUspeh-2016", where the same sector is the leading one by the share of R&D investment and the share of expenditures on technological innovations by revenue (National ranking of rapidly growing technological companies "TechUspeh-2016", 2016). In addition, we can see a trend that results of research and development have increase from 2012 to 2016 in average by every industry. Thereby, we can conclude that the interest in innovation activities increases in Russia over the last years that proves the relevance of our research.

However, the results related to the amount of R&D investment of Russian companies are very different in comparison to similar foreign studies. For instance, in (Bae and Kim, 2003) the average amount of R&D investment in the U.S. $96 million that is 7 times higher than for Russia. Moreover, the obtained results are confirmed by the analysts: " The leader in innovation is South Korea which has spent 4,23% of GDP in 2015. Further, Japan – 3.29%, Germany – 2.93%, the USA - 2.79%. Russia is on the 11th place with R&D expenses equual to 1.1%. og GDP" (Manukov, S, 2017). Such a difference can be explained by the fact that most of the foreign studies considered IT sector, for which innovation activities is a key success factor. In Russian conditions the number of such companies is limited especially then it comes to public companies. Another explanation follows from the fact that the quality of R&D activities and their applicability on the specific conditions are not always comparable to their allocated funds. In addition, it should be noted that we consider only those R&D expenditures that turned out to be sucessful. Therefore, since not all the expenditures are usually sucessful due to the elevated risks, these results can be treated as quite reasonable.

We have also analyzed the distribution of registered patents among industries and have found that the most heavily patented sector is the oil and gas industry (Figure 7).

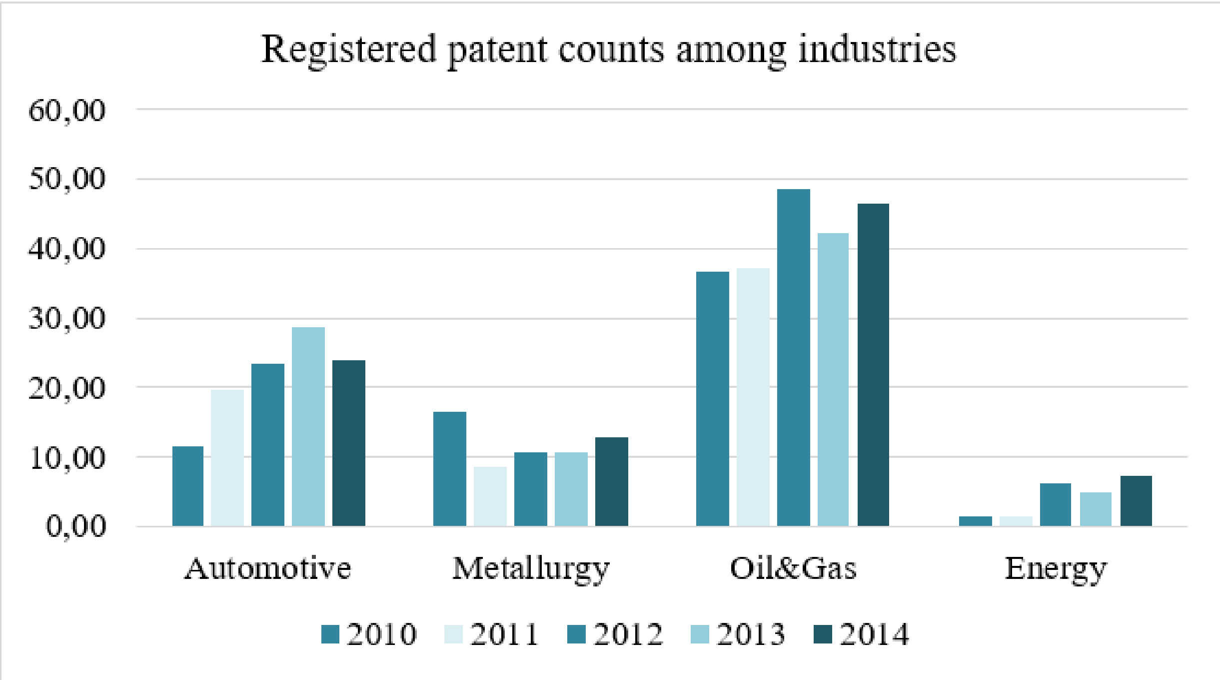

Figure 7: Registered patent counts among industries. (Author's analysis).

The predominant technologies they patent are the oil and gas extracting and processing (Volkov, Shepelev, 2015). For instance, the company "Gazprom" has a significant number of patents in the hydrocarbon transportation field due to the owning of the world's longest gas transportation system. Another reason for the high level of patenting and increase of its amount in the Russian oil and gas companies lies in the world geopolitical situation. Previously companies were not interested in the development of innovation activities as the overwhelming majority of technological problems faced by companies could be solved by the use of existing import technologies. However, recently the import of technologies into the domestic oil and gas industry was banned and Russian companies started to reconsider their strategies regarding their internal innovative development. These reasons are also appropriate for the increase of patenting activity in other industries.

Chapter 3. Empirical results and discussion

3.1. Statistical results of the regression analysis

How it was already stated for the empirical research there were chosen two indicators of financial performance: return on assets (ROA) and Tobin's Q ratio. Further, to identify innovation activity there were chosen two variables: R&D results and the number of registeref patents.

The first model we have built describes the interrelation between innovation activities and ROA. The results of the model you can see below (Table 6).

Table 6. Regression analysis results

	$\mathbf{ROA_{i,t}}$	
Variable	**1**	**2**
$RD_{i,t-1}$	0.165**	-
$RD^2_{i,t-1}$	-0.005**	-
$PAT_{i,t-2}$	-	-0.001
$REV_{i,t}$	0.207***	0.198***
$LEV_{i,t}$	-0.008*	-0.037*
Cons	-6.264***	-4.843***
R^2	21,57%	16.3%
p-value	0.0000	0.0000
N	212	212

***significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level
Source: author's analysis.

As we are working with panel data, we have run three regression models: pooled, fixed effects and random effects model and, then, have to choose the most adequate model for our dataset. For this reason, we carried out a pairwise comparison of the estimated models using the Wald test, Breusch and Pagan Lagrangian multiplier test and Hausman test. Based on the obtained results we can conclude that in this case the fixed effects model is the best suited for our data. One of the characteristics of the fixed effects model is the fact that it is not possible to include and test the effect of dummy variables. However, since included into the regression dummy variables indicating whether the company operates in a particular industry are not statistically significant in both pooled and random effects model, we still cannot estimate their effect. Therefore, the omission of these variables is not the obstacle for using this model for further interpretation.

The value of coefficient of determination (R^2) for the model with R&D results, which demonstrate the explanatory power of the considered model, is approximately 22%. This means that value of financial performance indicator (ROA) can be explained by the regression model for 22% of the variance. The model with the number of registered patents as a variable reflecting innovation activity has a coefficient of determination (R^2) equal to 16.3% that means that only this part of the variance can be explained by the regression model.

Both models are statistically significant that means we are able to interpret the results. However, referring to the innovation activity variables, the results varied. Both coefficient before variables R&D results and squared R&D results were significant. Therefore, we can come to conclusion that there is a non-linear relationship between R&D results and accounting-base financial performance measured as firm's return on assets (ROA). However, we obtained non-significant coefficient before the variable characterizing the number of registered patents, consequently on the basis of this results is not possible to conclude that there is a positive relationship between the number of registered patents and the company performance measured as a return on assets.

Referring to relationship between research and development results and firm's performance it is important to note that R&D investment depends on its amount and overinvestment can lead to the negative influence on the firm's financial performance. Since we found that relationship between R&D investment and financial performance are non-linear, we can calculate the transition point from which R&D investment negatively affect the firm's performance and visually demonstrate the function of this relationship. To calculate this, first we have to find a first order partial derivative, then we have to find a second order partial derivative:

$$\frac{\partial ROA_{i,t}}{\partial lnRD_{i,t-1}} = \beta_1 * \ln RD_{i,t-1} + \beta_2 * \ln RD_{i,t-1}^2$$

$$\frac{\partial ROA_{i,t}}{\partial lnRD_{i,t-1}} = 0.165 * \ln RD_{i,t-1} - 0.005 * \ln RD_{i,t-1}^2$$

$$\ln RD_{i,t-1} = \frac{0.165}{2 * 0.005} = 15.18$$

$$RD = 3\ 913\ 428$$

$$\frac{\partial^2 ROA_{i,t}}{\partial^2 lnRD_{i,t-1}} = 2 * \beta_2 = 2 * (-0.005) = -0.11 < 0$$

Since the second order partial derivative is negative (less than 0), we are able to conclude that function of firm's performance interrelation with R&D investment results is concave and can plot a graph (see the Figure 8). Therefore, the results of the first two variables indicate that the relationship between innovation activities measured as R&D expenditures and accounting-based financial performance depends on the amount of investment. The transition point from which the relationship between R&D results and ROA become negative is approximately 4 million rubles.

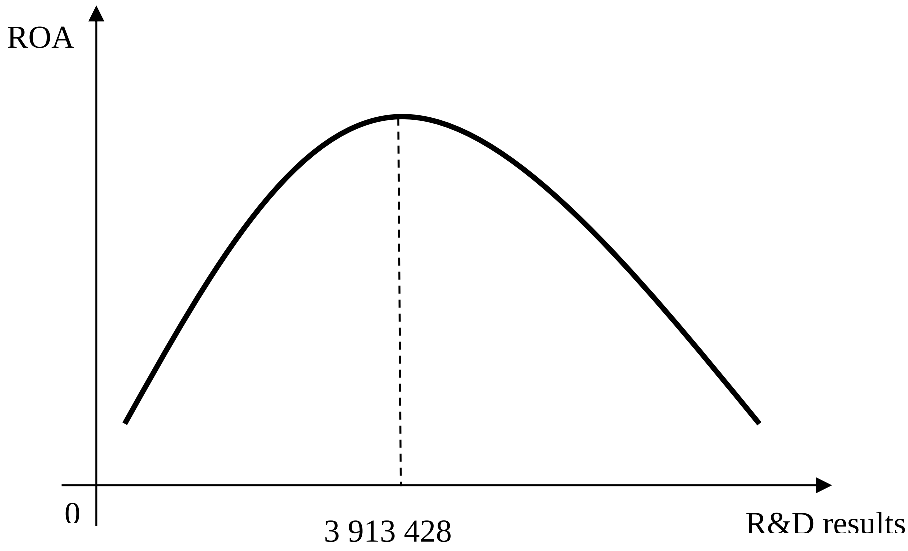

Figure 8. Dependence of ROA on R&D results. (Author's analysis).

The second model was developed in order to estimate the relationship between innovation activity measured as R&D results and the number of patents and firm's market-based financial performance measured as Tobin's Q ratio. Results of the model you can see below (Table 7):

Table 7. Regression analysis results

	$TQ_{i,t}$	
Variable	**1**	**2**
$RD_{i,t-1}$	0.306**	-
$RD^2_{i,t-1}$	-0.008**	-
$PAT_{i,t-2}$	-	-0.001
$REV_{i,t}$	0.302***	0.295***
$LEV_{i,t}$	-1.041***	-1.047***
Cons	-9.941***	-7.023***
R^2	27,81%	29.17%
p-value	0.0000	0.0000
N	212	212

***significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level
Source: author's analysis.

Like in the case of the models with ROA, we have built three regressions: pooled, fixed effects and random effects model and running Wald test, Breusch and Pagan Lagrangian multiplier test and Hausman test came to conclusion that fixed effects model is the best suited for this particular data as well.

All the models provided in the table X turned out to be statistically significant, therefore we are able to interpret the results. The value of coefficient of determination (R^2) for the model with R&D results is about 28%. This tells us that the obtained results can be explained only for 22% of the variance. The second model with the number of patents has an explanatory power only for about 29% of the regression.

Again only the coefficient before the variables R&D results and squared R&D results were significant, while the coefficient before the number of patents appeared insignificant. Therefore we can conclude that there is a non-linear relationship between R&D results and market-based financial performance. Referring to the number of patents, we cannot interpret the results and reject the hypothesis about positive relationship between the number of registered patents and market-based financial performance.

To estimate the transition point from which R&D investment negatively affect the firm's performance and visually demonstrate the function of this relationship again we carried out the following computations: first, we found a first order partial derivative, then a second order partial derivative:

$$\frac{\partial TQ_{i,t}}{\partial lnRD_{i,t-1}} = \beta_1 * \ln RD_{i,t-1} + \beta_2 * \ln RD_{i,t-1}^2$$

$$\frac{\partial TQ_{i,t}}{\partial lnRD_{i,t-1}} = 0.306 * \ln RD_{i,t-1} - 0.008 * \ln RD_{i,t-1}^2$$

$$\ln RD_{i,t-1} = \frac{0.306}{2 * 0.008} = 18.09$$

$$RD = 72\ 091\ 855\ 990$$

$$\frac{\partial^2 TQ_{i,t}}{\partial^2 lnRD_{i,t-1}} = 2 * \beta_2 = 2 * (-0.008) = -0.017 < 0$$

The second order partial derivative is negative (less than 0), thus our function of firm's performance interrelation with R&D investment results is concave (see the Figure 9). The second model based on market performance the relationship between innovation activities measured as R&D expenditures and performance again prove a non-linear nature of relationship that depends on the amount of R&D investment.

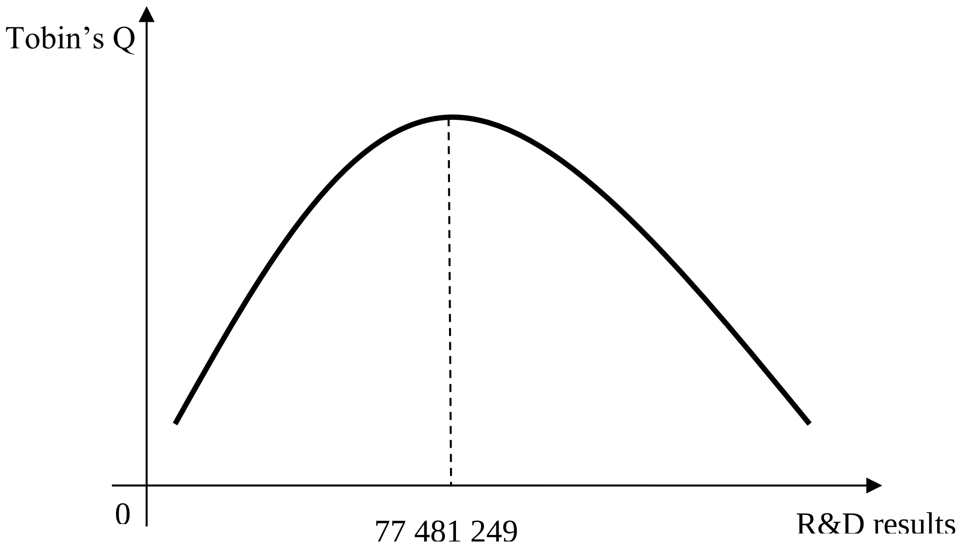

Figure 9. Dependence of ROA on R&D results. (Author's analysis).

The second part was dedicated to the revealing of factors that can affect the R&D results. The results are provided in the Table 8 below:

Table 8. Regression analysis results

Variable	$RD_{i,t}$ (random effects)
$SIZE_{i,t}$	0.77***
$HR_{i,t}$	$6.09e^{-7}$**
$CAPINT_{i,t}$	6.67***
$LEV_{i,t}$	-0.226*
$oil_{i,t}$	-2.411**
$energy_{i,t}$	-1.732**
$metall_{i,t}$	-1.64*
Cons	-0.767
R^2	40.73%
p-value	0.0000
N	202

***significant at the 0.01 level
** significant at the 0.05 level
* significant at the 0.1 level
Source: author's analysis

The panel data models again were tested by Wald, Breusch-Pagan and Hausman tests, hence, it was concluded that the random effects model most adequately describes the available empirical data. The model is statistically significant. Considering the individual variables, we got statistically significant coefficients for the following variables: the size of the company expressed as its revenue, quality of human resources expressed as the ratio of employee expenses to revenue, the ratio of depreciation cost to revenue reflecting firm's capital intensity, company's leverage and all the dummy variables describing the industry of considered companies. The constant variable turned out to be insignificant. Therefore, we can accept all the hypotheses related to the relationship between R&D results and firm's internal resources.

3.2. Discussion of the results

At the beginning of the analysis, there were proposed 6 hypotheses. Further, these hypotheses were tested using the regression models and then, on the base of these obtained results we can accept or reject the initially stated hypotheses. The results of conducted research allows us to draw conclusions about the existence of relationship between innovation activity and financial performance of companies. Moreover, the financial performance is considered from two perspectives: as a return on assets (that mostly reflect the operating performance of the company) and as a Tobin's Q ratio (that describe the market perception of a company's activities). Then, the results of the second part of regression analysis allow us to find the characteristics of relationship between innovation activities measured as R&D results and internal company's factors such as firm's size, capital intensity, quality of human resources, and leverage. The information gained from the regression analysis is summarized in the Table 9.

Table 9. Proved and not proved hypotheses

Hypothesis	Result of the analysis
There is a **non-linear correlation** between results of research and development and financial performance in Russian public companies.	Proved
There is a **positive correlation** between the number of patents and financial performance in Russian public companies.	Not proved
There is a **positive correlation** between size of the company and its results of research and development.	Proved
There is a **positive correlation** between the quality of human resources and its results of research and development.	Proved
There is a **positive correlation** between the firm's capital intensity and its results of research and development.	Proved
There is a **negative correlation** between the firm's leverage and its results of research and development.	Proved

Source: author analysis

According to obtained results we accept the hypothesis about a non-linear correlation between results of research and development and financial performance in Russian public companies on the both levels – if the performance is measured as return on assets (accounting-based) and if it is measured as Tobin's Q ratio (market-based). These findings are consistent with the results of the previous researches that were conducted mainly in the developed European and American markets (Pantagakis, Terzakis, Arvanitis, 2012; Beld, 2014). These results tells us that unlimited investment in R&D activities without due forethought does not guarantee an increase of a company's financial performance.

In addition, we have found the transition points from which R&D investment start to show negative relationship with the company's financial performance. The interesting fact is that this point for ROA and Tobin's Q vary considerably. In case of ROA (accounting-based performance), the point from which the relationship turns out to be negative is too low (approximately 4 million rubles) while in the case with Tobin's Q ratio (market-based performance) is much higher (approximately 77.5 million rubles).

Only 8 companies out of 45 reported R&D results less than 4.5 million rubles in different years which is about 8% of considered sample. These companies are PJSC "OGK-2", PJSC "KTK", PJSC "Raspadskaya", PJSC "Chelyabinsk Metallurgical Plant", PJSC "Chelyabinsk forge-and-press plant", PJSC "Yakutskenergo", PJSC "Omskshina", PJSC "Southern Kuzbass". According to the national report on the management of research and development in Russian companies, for large firms innovations related to the improvement of already existing products and technologies is more important than a creation of fundamentally new products. On the contrary, smaller firms show exactly opposite priorities (Management association, 2011). Therefore, large corporation are aimed rather at the retention of already existing markets than take a risk on new directions. Innovation activity for large companies provide mostly incremental innovation and may not have a great positive influence on ROA. At the same time, smaller companies that generate less revenue are more sensitive to R&D results in terms of operational performance (ROA), while for bigger companies there are other more important factors that can affect ROA. As an example PJSC "AVTOVAZ", a leader of investment in R&D, has invested from 3.5 to 10 billion rubles for the last 5 years that is in average 4% of its revenue, however it also reported net losses 44.8 billion in 2016 (AVTOVAZ, 2016). The main reason for such a big loss is the downtime of non-current assets, the company used very little of its production capacity because of the fallen demand (RBK, 2016). Moreover, to conduct a radical innovation the large companies need to complete modernization processes and reduce technological gap in order to reduce costs and improve their products achieving a minimum competitive level. Representatives of PJSC "Bashneft" note that the technology market is monopolized by Western companies and it is quite complicated to recover scientific school and solid research and development base for the internal development (Management association, 2011). Another problem companies may face may be a quality of innovation management. Only 8% of Russian companies consider themselves as leaders in the field of creating and implementing innovations. For comparison, the number of such companies in BRICs countries is 22%. Such a gap exists despite the fact that Russian companies are increasingly making serious investments in innovations. This indicates a significant potential for improving the effectiveness of innovation management in Russian business (PWC, 2013). Another explanation of such a result can be a necessity to consider a bigger time lag, since 1 year can be not enough for a tangible impact on operating performance.

Reffering to correlation between R&D results and Tobin's Q ration, which reflect the market value of a company, in 66.2% of cases investigated companies invested in R&D less than 77.5 million rubles. Hence, we can conclude that in most of the cases the relationship between innovation activity and its market-based financial performance is positive, research and development activities are managed quite effectively and increase the credibility of company, which in turn lead to an increase in its market value of shares.

However, running the regression analysis using a number of registered patents in both cases (for accounting-based and market-based performance indicator as a dependent variable) the coefficient before the number of patents was not statistically significant. Hence, we reject the hypothesis about a positive correlation between the number of patents and financial performance in Russian public companies.

Furthermore, the results of the study allow concluding that there is a correlation between the R&D investment and firm's internal resources. Performing this study there was found a statistically significant positive relationship between size of a company and its R&D intensity. These results are consistent with the previous research findings on a foreign markets (Park, Shin and Kim, 2010). Hence, we can conclude that firms that are larger and consequently, have greater market power and smaller risks have a higher willingness to invest in R&D. The hypothesis about positive correlation between the quality of human resources was also accepted. According to the report on the Deloitte research results, the employees have a crucial impact on a company's innovation activity (Deloitte, 2016). It allows us to suppose that knowledge and experience of personnel, their professional skills contribute to a greater innovation activity of a company, though the coefficient and, consequently, this contribution is quite small. Moreover, it was found that higher capital intensity of a company corresponds to a higher R&D investment. These findings are consistent with the previous research (Dalziel, Gentry, & Bowerman, 2011; Park, Shin and Kim, 2010). Likewise, the hypothesis about negative relationship between company's leverage and R&D results was accepted. Hence, we suppose that a higher debt burden associated with the increase of risk negatively affect the R&D-investment decisions since this activity is also quite risky.

Therefore, according to obtained results, companies should not be reluctant to invest in R&D if they want to increase their market value since the market perceive it as a positive sign for a company's development that increase its credibility for the investors. However, this investment should be justified and if companies want to increase its operational performance significantly, they should focus not only on the incremental, but also radical innovation. With regard to an increase of R&D investment, it is reasonable to take into consideration its correlation with size, quality of human resources, capital intensity and leverage.

The experience and knowledge of staff and developing highly valuable fixed assets may help the company to make decisions that further increase its financial performance.

Conclusion

This paper is devoted to the study of the relationship between innovation activity and financial performance of Russian public companies.

The research goal is to identify whether the innovation activity is related to the market-based and accounting-based performance and what are the features of this relationship.

The first chapter was dedicated to the literature review of innovation activities and firm's financial performance. There were defined the most common indicators of financial performance both accounting-based and market-based. There was provided the terminology of innovation and innovation activities and their main characteristics. Then, there was examined previous studies in order to define how innovation activities can be measured and what factors affect R&D investment as the most commonly applied indicator of firm's innovation activity.

In the second chapter there was conducted an empirical study of relationship between innovation activity and financial performance. The research hypotheses were stated, the methodology of the empirical research was defined, the data selection justification and its description analysis were provided.

In the third chapter there were provided the results of econometric analysis. The research was conducted on a sample of Russian public companies, which in the period from 2012 to 2016 carried out the research and development expenditures and patents' registration, which could be used in their core business. Then, on the base of this analysis the conclusions and further recommendations were provided.

According to the conducted regression analysis the following conclusins were made:

1) There is a non-linear correlation between results of research and development and financial performance in Russian public companies on the both levels – if the performance is measured as return on assets (accounting-based) and If it is measured as Tobin's Q ratio (market-based).
2) The implemented innovation products and technologies obtained as a result of R&D investments contribute to the company's greater financial performance only up to a certain point and this point vary significantly for accounting-based and market-based performance. The lower transition point for ROA is probably caused by an incremental nature of innovation and the existence of other factors that may demonstrate a greater impact on a company's financial performance. Another explanation lays in the choice of appropriate time lag between R&D investment and financial performance. In most cases, the considered companies demonstrate positive relationship between their innovation activity and Tobin's Q ratio. Consequently, it

can be supposed that R&D activities are managed quite effectively and increase the credibility of company, which in turn lead to an increase in its market value of shares.

3) The hypothesis about a positive correlation between the number of patents and financial performance was rejected since the coefficients for the variables describing the number of patents turned out to be statistically insignificant.
4) There is a positive correlation between firm’s internal resources such as company’s size, quality of human resources, capital intensity and R&D results. Likewise there was found a negative correlation between company’s leverage and its R&D intensity.

Therefore, according to obtained results, companies should not be reluctant to invest in R&D if they want to increase their market value. However, this investment should be justified and if companies want to increase its operational performance significantly, they should focus not only on the incremental, but also radical innovation. With regard to an increase of R&D investment, it is reasonable to take into consideration its correlation with size, quality of human resources, capital intensity and leverage.

It should be emphasized that the obtained results have a number of limitations. The sample consists of only public Russian companies. The list of industries includes only oil&gas, energy, automotive and metallurgy industries and can be extended further. In addition,there were considered only two indicators of innovation activities – R&D investment and a number of patents. Finally, the information was partially missing for some companies that required a diminishing of the initial sample. Thus, the examined topic remains relevant and may have many directions for a further investigation.

References

1. Abreu, M., Grinevich, V., Kitson, M., Savona, M. (2011). The changing face of innovation policy: implications for the Northern Ireland economy, DETI Department of Trade and Industry Northern Ireland.
2. Acs, Z., Anselin, L. and Varga, A. (2002). Patents and innovation counts as measures of regional production of new knowledge. Research Policy, 31(7), pp.1069-1085.
3. Analytical Center under the Government of the Russian Federation (2014). Strategy of innovation development of Russian Federation for the period until 2020. [online] / Available at: http://ac.gov.ru/publications/ [Accessed 20 May 2018].
4. Annavarjula, M., Mohan, R., Beldona, S. (2008). Technological Innovation and the Market Value of Firms. Communications of the IBIMA, Vol. 2.
5. Arora, A., Ceccagnoli, M., Cohen, W.M. (2008). R&D and the patent premium. International Journal Industrial Organization, 26, pp. 1153–1179.
6. AVTOVAZ (2016). Annual financial report. [online] / Available at: https://www.e-disclosure.ru/portal/files.aspx?id=31&type=3 [Accessed 20 May 2018].
7. Bae, S. and Kim, D. (2003). The Effect of R&D Investments on Market Value of Firms: Evidence from the U.S., Germany, and Japan. Multinational Business Review, 11(3), pp.51-76.
8. Beld B. (2014). The effects of R&D investment on firm performance. IBA Bachelor Thesis Conference.
9. Berzkalne, I. and Zelgalve, E. (2014). INNOVATION AND COMPANY VALUE: EVIDENCE FROM THE BALTIC COUNTRIES. Regional Formation and Development Studies, 11(3).
10. Bessen, J. (2008). The Value of U.S. Patents by Owner and Patent Characteristics. Research Policy 37, pp. 932-945.
11. Brouwer, M. (1991). Schumpeterian Puzzles: Technological competition and economic evolution. University of Michigan Press, Michigan.
12. Burhan, M., Singh, A., Jain, S. (2017). Patent as a proxy for measurement innovations: A case of changing patent filing behavior in Indian public funded research organizations. Technological Forecasting & Social Change 123, pp. 181-190.
13. Chauvin, K. and Hirschey, M. (1993). Advertising, R&D Expenditures and the Market Value of the Firm. Financial Management, 22(4), p.128.
14. Chen, S., Dodd, J. (1997). Economic Value Added (EVA): An Empirical Examination of a New Corporate Performance Measure. Journal of Managerial Issues, 9(3), pp. 318-333.
15. Civil Code of the Russian Federation (1994). Part 1 from 20.11.1994 N 51-FZ (eds 29.12.2017). Article 66.3. Public and non-public organizations.

16. Coad, A., Rao, R. (2010). Firm growth and R&D expenditure. Economics of Innovation and New Technology, 19(2), pp. 127–145.
17. Cohen, W., (1995). Empirical studies of innovative activity. In: Stoneman, P. (Ed.), Handbook of the Economics of Innovation and Technological Change. Blackwell, Oxford, pp. 182–264.
18. Connolly R., Hirschey M. (2005) Firm size and the effect of R&D on Tobin's q. R&D Manage, Mar 35(2), pp. 217–223.
19. Dalziel, T., Gentry, R., Bowerman, M. (2011). An integrated agency-resource dependence view of the influence of directors' human and relational capital on firms' R&D spending. Journal of Management Studies, 48(6), pp. 1217–1242.
20. Damodaran, A. (2002). Investment valuation. New York: Wiley.
21. Del Canto, J. and González, I. (1999). A resource-based analysis of the factors determining a firm's R&D activities. Research Policy, 28(8), pp.891-905.
22. Deloitte (2016). The effectiveness of government support mechanism of R&D in Russia. Report on research results, Moscow. [online] / Available at: https://www2.deloitte.com/content/dam/Deloitte/ru/Documents/tax/razvitie-niokr-v-rossii.pdf [Accessed 20 May 2018].
23. Diederen, P. and Geroski, P. (1996). Market Structure, Corporate Performance and Innovative Activity. The Economic Journal, 106(434), p.220.
24. Dobbs, R., Koller, S. (2005). Measuring long-term performance. McKinsey Quarterly №1 [online] / Available at: http://www.mckinsey.com/insights/corporate_finance/measuring_long-term_performance [Accessed 20 May 2018].
25. Doukas, J. and Switzer, L. (1992). The stock market's valuation of R&D spending and market concentration. Journal of Economics and Business, 44(2), pp.95-114.
26. Drucker, P. (2002). The Discipline of Innovation Harvard Business Review.
27. E. du Toit, J. de Wet. (2007). Return on Equity: a popular, but flawed measure of corporate financial performance. South African Journal of Business Management, Vol. 38, N. 1, pp. 59-69.
28. FASB (2010). Statement of Financial Accounting Standards, No. 142. Goodwill and Other Intangible Assets. [online] / Available at: http://www. fasb.org/pdf/fas142.pdf [Accessed 20 May 2018].
29. Federal Act of 23 August 1996 N 127-FZ on “Science and state scientific and technical policy” (version of 23 May 2016). [online] / Available at: http://www.consultant.ru/document/cons_doc_LAW_11507/c0a49fc869aeeb5b28ca88d3d37b7d8f7474375f/ [Accessed 20 May 2018].
30. Firer, C., Ross, S., Westerfield, R. and Jordan, B. (2012). Fundamentals of corporate finance. London: McGraw-Hill Higher Education.

31. Fishman, A., Rob, R. (1999). The size of firms and R&D investment. International Economic Review, 40(4), pp. 915–931.
32. Fleming, L. (2001). Recombinant uncertainty in technological search. Management Science, 47, pp. 117–132.
33. Galende, J. and de la Fuente, J. (2003). Internal factors determining a firm's innovative behaviour. Research Policy, 32(5), pp.715-736.
34. García-Manjón, J. and Romero-Merino, M. (2012). Research, development, and firm growth. Empirical evidence from European top R&D spending firms. Research Policy, 41(6), pp.1084-1092.
35. Geroski, P. (1994). Market structure, corporate performance and innovative activity. Oxford: Clarendon Press.
36. Giudici, G., Paleari, S., (2000). The provision of finance to innovation: a survey conducted among Italian technology-based small firms. Small Business Economics 14, pp. 37–53.
37. Gotsch, M. and Hipp, C. (2012). Measurement of innovation activities in the knowledge-intensive services industry: a trademark approach. The Service Industries Journal, 32(13), pp.2167-2184.
38. Hagedoorn, J. and Cloodt, M. (2003). Measuring innovative performance: is there an advantage in using multiple indicators?. Research Policy, 32(8), pp.1365-1379.
39. Hagel, J., Brown, J. S., Davison L. (2010). The Best Way to Measure Company Performance. HBR blog network. [online] / Available at: https://hbr.org/2010/03/the-best-way-to-measure-compan [Accessed 20 May 2018].
40. Hall, B. (1999). Innovation and Market Value. SSRN Electronic Journal.
41. Hall, B., Jaffe A., Trajtenberg M. (2005). Market value and patent citations, RAND Journal of Economics, 36 (1). https://www.rvc.ru/upload/iblock/293/Buklet_Rezultaty_issledovaniya_TehUspeh.pdf [Accessed 20 May 2018].
42. Jaffe, A., Trajtenberg, M. (2002). Patents, Citations, an Innovations: A Window on the Knowledge Economy, MIT Press.
43. Jaruzelski, B., Loehr, J., Holman, R. (2011). The Global Innovation 1000. Why Culture is Key? Strategy&.
44. Jaskyte, K. (2011). Predictors of administrative and technological innovations in nonprofit organizations, Public Administration Review. pp. 77-86.
45. Kleinknecht, A., Montfort, K., Brouwer, E., (2002). The Non-trivial choice between Innovation Indicators. Economics of Innovation and New Technology11(2) pp. 109-121.

46. Koller, T., Goedhart, M. and Wessels, D. (2015). Valuation: Measuring and Managing the Value of Companies. Hoboken: Wiley & Sons.
47. Kovalev, V. (2004). Financial accounting and analysis. Finance and statistics.
48. Kraft, K., Czarnitzki, D. (2002). Measuring the Impact of Innovation on Firm Value: A New Approach. ZEW Discussion Papers, No. 02-73.
49. Lai, Y., Lin, F. and Lin, Y. (2015). Factors affecting firm's R&D investment decisions. Journal of Business Research, 68(4), pp.840-844.
50. Management Association (2011). Management of research and development in Russian companies. National report, Moscow. [online] / Available at: https://www.hse.ru/news/science/39167953.html [Accessed 20 May 2018].
51. Manukov, S. (2017). When innovation leads to nothing. Expert online. [online] / Available at: http://expert.ru/2017/10/17/pochemu-innovatsii-ni-k-chemu-ne-privodyat/ [Accessed 20 May 2018].
52. Mendonça, S., Pereira, T., Godinho, M. (2004). Trademarks as an Indicator of Innovation and Industrial Change, Resrarch Policy, 33(9), pp.1385-1404.
53. Molchanov, N. (2014). Marketing of innovation: textbook and practical guide for undergraduates. Yurayt, Moscow.
54. OECD (2009). OECD Patent Statistics Manual, OECD Publishing, Paris.
55. OECD (2013), OECD Science, Technology and Industry Scoreboard 2013: Innovation for Growth, OECD Publishing, Paris.
56. OECD, (2015). Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris.
57. OECD/Eurostat (2005), Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition, The Measurement of Scientific and Technological Activities, OECD Publishing, Paris.
58. Pantagakis, E., Terzakis, D. and Arvanitis, S. (2012). R&D Investments and Firm Performance: An Empirical Investigation of the High Technology Sector (Software and Hardware) in the E.U. SSRN Electronic Journal.
59. Park, Y., Jaeun, S., Kim, T. (2010). Firm size, age, industrial networking, and growth: A case of the Korean manufacturing industry. Small Business Economics., 35, pp. 153–168.
60. Parmenter, D. (2015). Key Performance Indicators (KPI): Developing, Implementing, and Using Winni. John Wiley & Sons.
61. PBU 17/02 (2002). Regulation on accounting "Accounting of expenditures on research and development".

62. Pindado, J., De Queiroz, V. and De La Torre, C. (2010). How Do Firm Characteristics Influence the Relationship between R&D and Firm Value?. Financial Management, 39(2), pp.757-782.
63. PWC (2013). Growth through innovations: Russian and international experience. [online] / Available at: https://www.pwc.ru/ru/innovationsurvey/assets/executive-summary-ru.pdf [Accessed 20 May 2018].
64. RBK (2016). AVTOVAZ is on the verge of bankruptcy. [online] / Available at: https://www.rbc.ru/business/28/07/2016/579a02499a7947b7408dcf26 [Accessed 20 May 2018].
65. Schumpeter, J. (1934). Theory of Economic Development. Cambridge: Harvard University Press.
66. Schumpeter, J. and Opie, R. (1961). The theory of economic development. Cambridge, Mass.: Harvard University Press.
67. Shi, X. and Wu, Y. (2017). The effect of internal and external factors on innovative behaviour of Chinese manufacturing firms. China Economic Review, 46, pp.S50-S64.
68. Shin, M., Kim, S. (2011). The Effects of R&D Expenditure on the Firm Value: Evidence from Korean Small and Medium Sized Enterprises. Journal of Finance and Accountancy, Vol. 7, pp. 1–20.
69. Sitnikova, V. (2017). Measurement of Research&Develoopment results. Financial Analytics: Science and experience, 10(1), pp. 49-56.
70. Sorescu, A. and Spanjol, J. (2008). Innovation's Effect on Firm Value and Risk: Insights from Consumer Packaged Goods. Journal of Marketing, 72(2), pp.114-132.
71. Strategy& (2017). Global Innovation 1000: Will Stronger Borders Weaken Innovation? [online] / Available at: https://www.strategyand.pwc.com/media/file/2017-Global-Innovation-1000-Fact-Pack.pdf [Accessed 20 May 2018].
72. TechUspeh, (2016). National ranking of rapidly growing technological companies. [online] / Available at:
73. Teirlinck, P. (2017). Configurations of strategic R&D decisions and financial performance in small-sized and medium-sized firms. Journal of Business Research, 74, pp.55-65.
74. Tobin, J. and Brainard, W. (1977). Asset markets and the cost of capital. New Haven, Conn.
75. Toivanen, O., Stoneman, P. and Bosworth, D. (2002). Innovation and the Market Value of UK Firms, 19891995. Oxford Bulletin of Economics and Statistics, 64(1), pp.39-61.
76. Tomiura, E. (2007). Effects of R&D and networking on the export decision of Japanese firms. Research Policy, 36, pp. 758–767.
77. UNESCO, (2014). Guide to conducting an R&D survey: For countries starting to measure research and experimental development. UNESCO Institute of Statistics, Montreal.

78. Vega-Jurado, J., Gutiérrez-Gracia, A., Fernández-de-Lucio, I. and Manjarrés-Henríquez, L. (2008). The effect of external and internal factors on firms' product innovation. Research Policy, 37(4), pp.616-632.
79. Vithessonthi, C. and Racela, O. (2016). Short- and long-run effects of internationalization and R&D intensity on firm performance. Journal of Multinational Financial Management, 34, pp.28-45.
80. Volkov, A., Shepelev, R. (2015). Patent activity in the oil and gas complex. University Journal, 9, pp. 11-17.
81. Volkov, D. (2008). The theory of value-oriented management: financial and accounting aspects. 2nd edition. Graduate School of Management.
82. Wang, Y., Wei, Y. and Song, F. (2017). Uncertainty and corporate R&D investment: Evidence from Chinese listed firms. International Review of Economics & Finance, 47, pp.176-200.
83. Weerawardena, J., O'Cass, A., Julian, C. (2006). Does industry matter? Examining the role of industry structure and organizational learning in innovation and brand performance. Journal of Business Research, 59, pp. 37–45.
84. Wernerfelt, B. (1984). A resource-based view of the firm. Strategic Management Journal, 5(2), pp.171-180.
85. Wolfe, J. (2003). The Tobin Q as a company performance indicator. Developments in Business Simulation and Experiential Learning, Volume 30, pp. 155-159.

Appendixes

Appendix 1. List of companies included in the sample

MICEX ticker	Company name	MICEX ticker	Company name
AVAZ	PJSC “AUTOVAZ”	NKSH	PJSC “Nizhnekamskshina”
ROSN	PJSC “NK Rosneft”	LKOH	PJSC “LUKOIL”
GAZP	PJSC “Gazprom”	LSNG	PJSC “LENENERGO”
RKKE	PJSC “RSC Energia”	MAGE	PJSC “Magadanenergo”
HYDR	PJSC “PusGidro”	KUBE	PJSC “Kubanenergo”
KMAZ	PJSC “KAMAZ”	NLMK	PJSC “NLMK”
TATN	PJSC “Tatneft”	OGKB	PJSC “OGK-2”
MSRS	PJSC “MOESK”	CHEP	PJSC “Chelyabinsk Tube-Rolling Plant”
GMKN	PJSC “MMC Norilsk Nikel”	VSMO	PJSC “VSMPO-AVISMA”
TRNF	PJSC “Transneft”	MRKY	PJSC “IDGS of South”
FEES	PJSC “FGC UES”	MRKS	PJSC “IDGS of Siberia”
SNGS	“Surgutneftegas”	MRKV	PJSC “IDGS of Volga”
SIBN	PJSC “Gazprom neft”	TORS	PJSC “TRK”
MAGN	PJSC “Magnitogorsk Iron and Steel Works”	TGKA	PJSC “TGC-1”
RUSP	PJSC “Ruspolimet”	MRKZ	PJSC “IDGS of North-West”
MRKC	PJSC “IDGS of Centre”	KBTK	PJSC “KTK”
ZVEZ	PJSC “ZVEZDA”	RASP	PJSC “Raspadskaya”
UNAC	PJSC “UAC”	CHMK	PJSC “Chelyabinsk

MICEX ticker	Company name	MICEX ticker	Company name
			Metallurgical Plant”
CHZN	PJSC “Chelyabinsk Zinc Plant”	CHKZ	PJSC “Chelyabinsk forge-and-press plant”
BANE	PJSC “Bashneft”	YKEN	PJSC “Yakutskenergo”
CHMF	PJSC “Severstal”	OMSH	PJSC “Omskshina”
UNKL	PJSC “Southern Urals Nickel”	UKUZ	PJSC “Southern Kuzbass”
MRKP	PJSC “IDGS of Center and Volga region”	-	-

Appendix 2. The descriptive statistics of variables for a model investigating relationship between innovation activity and financial performance

```
. sum ROA TQ  RD PAT LEV REV
```

Variable	Obs	Mean	Std. Dev.	Min	Max
ROA	212	.106391	.1370573	-.2908	.5471
TQ	212	.9097263	.4977392	.1462306	2.567305
RD	212	3.91e+08	1.34e+09	450000	1.27e+10
PAT	212	18.57075	44.6245	0	262
LEV	212	.5530071	.3485362	.030271	1.775889
REV	212	3.20e+11	8.05e+11	1.30e+09	4.33e+12

Appendix 3. The descriptive statistics of variables for a model with factors affecting R&D investment.

```
. summarize  RD SIZE HR CAPINT LEV
```

Variable	Obs	Mean	Std. Dev.	Min	Max
RD	202	4.34e+08	1.33e+08	450000	1.05e+10
SIZE	202	3.50e+11	8.36e+11	1.30e+09	4.33e+12
HR	202	.1119107	.0906669	.0000572	.6221322
CAPINT	202	.088168	.047946	.0005687	.2566875
LEV	202	.5821839	.4765001	.030271	3.937711

Appendix 4. The results of regression analysis for a linear model with the number of patents as an indicator of innovation activity and ROA as a dependent variable (fixed effects model)

```
. xtreg ROA PAT oil energy metall lnREV LEV, fe
note: oil omitted because of collinearity
note: energy omitted because of collinearity
note: metall omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =       212
Group variable: company                         Number of groups   =        45

R-sq:  within  = 0.2759                         Obs per group: min =         1
       between = 0.2275                                        avg =       4.7
       overall = 0.1630                                        max =         5

                                                F(3,164)           =     20.83
corr(u_i, Xb)  = -0.9253                        Prob > F           =    0.0000

------------------------------------------------------------------------------
         ROA |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         PAT |  -.0004576   .0003707    -1.23   0.219    -.0011895    .0002743
         oil |          0  (omitted)
      energy |          0  (omitted)
      metall |          0  (omitted)
       lnREV |   .1978228   .0258342     7.66   0.000     .1468122    .2488334
         LEV |  -.0374485   .0205399    -1.82   0.070    -.0031083    .0780054
       _cons |   -4.84332   .6496572    -7.46   0.000     -6.12609   -3.560549
-------------+----------------------------------------------------------------
     sigma_u |  .30080863
     sigma_e |  .06449727
         rho |  .95604769   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(44, 164) =    14.37             Prob > F = 0.0000
```

Appendix 5. The results of regression analysis for a non-linear model with the R&D results as an indicator of innovation activity and ROA as a dependent variable (fixed effects model)

```
. xtreg ROA  lnRD lnRD2 oil energy metall lnREV LEV, fe
note: oil omitted because of collinearity
note: energy omitted because of collinearity
note: metall omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =       212
Group variable: company                         Number of groups   =        45

R-sq:  within  = 0.3288                         Obs per group: min =         1
       between = 0.2784                                        avg =       4.7
       overall = 0.2157                                        max =         5

                                                F(4,163)           =     19.96
corr(u_i, Xb)  = -0.9223                        Prob > F           =    0.0000

------------------------------------------------------------------------------
         ROA |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnRD |   .1654126   .0767409     2.16   0.033     .0138781    .3169471
       lnRD2 |  -.0054484   .0022096    -2.47   0.015    -.0098115   -.0010853
         oil |          0  (omitted)
      energy |          0  (omitted)
      metall |          0  (omitted)
       lnREV |   .2068528   .0249318     8.30   0.000     .1576219    .2560838
         LEV |  -.0087946   .0214183    -1.75   0.082    -.0334985    .0510877
       _cons |  -6.263259    .923352    -6.78   0.000    -8.086533   -4.439985
-------------+----------------------------------------------------------------
     sigma_u |  .28561523
     sigma_e |  .06228526
         rho |  .95460265   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(44, 163) =    12.33             Prob > F = 0.0000
```

Appendix 6. The results of regression analysis for a linear model with the number of patents as an indicator of innovation activity and Tobin's Q as a dependent variable (fixed effects model)

```
. xtreg TQ PAT oil energy metall lnREV LEV, fe
note: oil omitted because of collinearity
note: energy omitted because of collinearity
note: metall omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =       212
Group variable: company                         Number of groups   =        45

R-sq:  within  = 0.7482                         Obs per group: min =         1
       between = 0.2202                                        avg =       4.7
       overall = 0.2917                                        max =         5

                                                F(3,164)           =    162.44
corr(u_i, Xb)  = -0.6339                        Prob > F           =    0.0000

------------------------------------------------------------------------------
          TQ |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         PAT |  -.0010054   .0008984    -1.12   0.265    -.0027793    .0007685
         oil |          0  (omitted)
      energy |          0  (omitted)
      metall |          0  (omitted)
       lnREV |   .2953702   .0626148     4.72   0.000     .1717351    .4190052
         LEV |  -1.046613   .0497829   -21.02   0.000     .9483147    1.144911
       _cons |   -7.02259   1.574583    -4.46   0.000    -10.13166   -3.913521
-------------+----------------------------------------------------------------
     sigma_u |  .54859877
     sigma_e |  .15632293
         rho |  .92490151   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(44, 164) =    20.74             Prob > F = 0.0000
```

Appendix 7. The results of regression analysis for a non-linear model with the R&D results as an indicator of innovation activity and Tobin's Q as a dependent variable (fixed effects model)

```
. xtreg TQ lnRD lnRD2 oil energy metall lnREV LEV, fe
note: oil omitted because of collinearity
note: energy omitted because of collinearity
note: metall omitted because of collinearity

Fixed-effects (within) regression               Number of obs      =       212
Group variable: company                         Number of groups   =        45

R-sq:  within  = 0.7506                         Obs per group: min =         1
       between = 0.2118                                        avg =       4.7
       overall = 0.2781                                        max =         5

                                                F(4,163)           =    122.64
corr(u_i, Xb)  = -0.6523                        Prob > F           =    0.0000

------------------------------------------------------------------------------
          TQ |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        lnRD |   .3058698   .1922706     2.48   0.014    -.0737925    .6855322
       lnRD2 |  -.0084525    .005536    -2.20   0.029     -.019384    .0024791
         oil |          0  (omitted)
      energy |          0  (omitted)
      metall |          0  (omitted)
       lnREV |   .3023412   .0624655     4.84   0.000     .1789954    .4256871
         LEV |  -1.041091   .0536626   -19.40   0.000     .9351277    1.147055
       _cons |  -9.941136   2.313414    -4.30   0.000    -14.50926   -5.373011
-------------+----------------------------------------------------------------
     sigma_u |  .56339997
     sigma_e |  .15605275
         rho |  .92874647   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(44, 163) =    19.49             Prob > F = 0.0000
```

Appendix 8. The results of regression analysis for a linear model with the relationship between R&D results and enterprise's internal factors (random effects model)

```
. xtreg  lnRD SIZE HR CAPINT LEV  oil gas metall, re

Random-effects GLS regression                   Number of obs      =       202
Group variable: company                         Number of groups   =        43

R-sq:  within  = 0.1837                         Obs per group: min =         1
       between = 0.4035                                        avg =       4.7
       overall = 0.4073                                        max =         5

                                                Wald chi2(7)       =     60.14
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
        lnRD |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        SIZE |   .7701358   .1559593     4.94   0.000     .4644612     1.07581
          HR |   6.09e-07   3.87e-07     2.45   0.015    -1.49e-07    1.37e-06
      CAPINT |    6.66982   2.070626     3.22   0.001     2.611468    10.72817
         LEV |  -.2259593   .1284405    -1.76   0.079     -.477698    .0257794
         oil |  -2.410591   1.015633    -2.37   0.018    -4.401195   -.4199875
      energy |  -1.732024   .8811737    -1.97   0.049    -3.459093   -.0049556
      metall |   -1.64975   .9342829    -1.77   0.077    -3.480911    .1814113
       _cons |  -.7672838   3.754764    -0.20   0.838    -8.126487    6.591919
-------------+----------------------------------------------------------------
     sigma_u |  1.6718927
     sigma_e |  .59515554
         rho |  .88753219   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```